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An Annotated Bibliography of the Quaternary Geology and History for the Don Valley Brickworks

by
R.I. Kelly, P.J. Barnett, and R.S. Delorme

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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS.

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877 quarts	1 quart	1.136 522		
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.103 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight perton (short)	0.05	ounces (troy) per ton (short)

Note. Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

An Annotated Bibliography of the Quaternary Geology and History for the Don Valley Brickworks

R.I.Kelly[1], P.J. Barnett[1], and R.S. Delorme[2]

[1]Geologists, Engineering and Terrain Analysis Section, Ontario Geological Survey, Toronto.

[2]Geological Assistant, Engineering and Terrain Analysis Section, Ontario Geological Survey, Toronto.

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Photo on front cover is of the Don Valley Brickworks, and was taken in 1913 by Professor A.P. Coleman.

Introduction

For over one hundred years, excavations at the Don Valley Brickworks provided the geological community with a unique glimpse into the Pleistocene history of the Great Lakes region (Figure 1). The various sedimentary units exposed at the site played an integral part in the construction of the Quaternary stratigraphic framework for both the Toronto area and for the region itself. Although the Brickworks section revealed many important Quaternary units, the site became world famous because of a fossil-rich last interglacial (Sangamonian) unit, known today as the Don Formation.

The scientific importance of this site has been recognized widely by the geological community. The type sections for the York Till (Illinoian), Don Formation and Pottery Road Formation have been designated at this locality. The Geological Society of America's Decade of North American Geology (DNAG) field guide for the Great Lakes region has recognized the Brickworks site as one of the important geological sites in North America. As well, the Ontario Ministry of Natural Resources has designated the Brickworks as a potentially significant earth science Area of Natural and Scientific Interest (ANSI).

According to C. Sauriol (1981), the origin of the Brickworks can be traced to the year 1882. During the spring of that year, William Taylor and an assistant were at work erecting a fence in the valley of the Don River. Clay being brought to the surface as postholes were being dug caught the attention of Taylor, who became curious as to its potential for brickmaking. The following day, Taylor packed two cigar boxes with the clay and took them to a local brickworks for firing. Here, Sauriol stated, a discussion took place between Taylor and the owner of the brickworks as to the colour of bricks which would be produced by firing. Taylor maintained that red bricks would result while the owner suggested that yellow ones would be produced. The clay did in fact produce very fine quality red-coloured bricks. Further testing on the site convinced Taylor and his brothers to establish a brickworks. The Ontario Bureau of Mines' Report for 1891 indicated that a full scale brickmaking operation did not begin at the site until 1891; however, a smaller operation had been producing bricks since 1889. By this time, the Brickworks had begun to utilize the Ordovician shale bedrock as raw material. The plant was capable of pressing some 44 000 bricks per day, and eight kilns on the site could handle an aggregate of 1 100 000 bricks. A total of 55 men were employed at the site.

Not long after excavations had started, numerous fossil remains were discovered in sandy stratified beds which overlie a lowermost till layer. Professor A.P. Coleman, a geologist from the University of Toronto, became interested in the site and published the first description of the fossils and the sediments in 1894. In this paper, Coleman listed fossils from the sandy beds which included *Pleurocera sp., Valvata sp., Sphaerium sp.*, many species of Unio, and wood specimens of oak, ash, and yew. The fossils and the fact that the beds were underlain and overlain by till layers suggested to Coleman that an interglacial period was preserved in these layers.

Based on his observations, of the Brickwork section and others around Toronto, Coleman outlined the following interpretation of the depositional history of the Quaternary of the Toronto area. Glacial ice invaded the Toronto area and spread a layer of till on the bedrock slope toward the hollow of Lake Ontario and then withdrew. A lake some 12 to 15 m above present level was formed, likely as a result of ice damming of the basin. Fauna and flora from the Mississippi River watershed invaded the area, although it was not known by what means. The climate in the region was similar to, or warmer than at present. Following deposition of the fossil-rich beds, the lake level rose to at least 42 m above the present level through damming of the eastern outlet by returning glacial ice. A further ice advance covered the sands and clays with a second till. As this ice front retreated, the lake level fell and glacial Lake Iroquois was formed.

Prior to Coleman's paper, a number of other earlier works reported finding fossils, some of probable interglacial age, in the drift sequences around Toronto. Fossils discovered in the Don Valley were first mentioned in papers published by E.J. Chapman and R. Bell in 1861. They found Melania and Unio ellipsis in sands located about 10 m above the level of Lake Ontario. In later years when the Don River was being straightened, J. Townsend and Dr. Brodie found numerous fossils near the Gerrard Street bridge, which were described in a paper published in 1890 by Sir William Dawson and Professor D.P. Penhallow. Penhallow identified two "maple" tree species which he concluded were extinct. Many years later, R.W. Brown (1942) established that Penhallow's extinct maples were in fact Platanus or Sycamore. During the remedial works on the Don River, Coleman also collected several Unios and other shells from a sand bed located 6 to 8 m above river level. The fossils were submitted to C.T. Simpson for identification. He reported that all of the fossil shells were in existence today, but were mainly restricted to the Mississippi River valley. Other early paleontological work was conducted by S.H. Scudder on fossil insects. Scudder's work concentrated mainly on samples taken from the Scarborough bluffs and specifically from the lower stratified clay-rich beds (Scarborough beds). The Scarborough beds, exposed at the bluffs, were considered to be interglacial in nature although their stratigraphic relationship with the layers at the Brickworks was not known until some years later. Scudder suggested that many of the species which were present were extinct forms. In addition, he proposed that the fossils which were identified inhabited a colder climate. Thus, the Scarborough beds were thought to have been deposited under more harsh climatic conditions, perhaps a boreal regime.

In addition to paleontological studies, many other early workers examined the problems of stratigraphic correlation of various drift sections and the position of interglacial beds in a developing Great Lakes region stratigraphic framework. One of the earliest papers to address stratigraphy was written by G.J. Hinde in 1877. In this paper, he described glacial and interglacial (Scarborough Beds) deposits exposed at the Scarborough Bluffs. Hinde recognized three till

Figure 1. *Diagram showing location of Don Valley Brickworks.*

layers; two intervening interglacial deposits, and postglacial stratified sand and gravel. Later, when the Don Brickworks sections were opened, Coleman (1894, 1895) attempted to correlate the Don Valley and Scarborough Bluff sections. In his 1894 paper, Coleman erroneously correlated the lowest till at the Brickworks (York Till) with the lowest till exposed at the bluffs (Sunnybrook Till). This meant that the Don beds were younger than the Scarborough beds. The following year, Coleman correlated the lower till of the bluffs with an upper till at the Brickworks, leaving the problem of relative ages of the Scarborough and Don beds unresolved. This problem was tackled in 1897 by a committee formed under the direction of the British Association for the Advancement of Science. Coleman wrote in an 1897 paper that the colder climate Scarborough beds were younger than the warmer climate beds at the Brickworks. The committee reported in 1899 that numerous diggings and borings along the Don River supported Coleman's 1897 interpretation. Additional reports by this committee (1900, 1901) added many fossil species to the previously published interglacial lists. Although the relative position of the strata was established, the Don and Scarborough beds were considered to represent a continuous interglacial deposit and for many years were together known simply as the Toronto Interglacial beds.

The age of the interglacial beds was a topic of controversy for many years. Professor Coleman reported in 1894 that the succession of beds at the Brickworks was difficult to assign to the stratigraphic classification of surficial deposits established by the Geological Survey of Canada report for 1863. In 1895, T.C. Chamberlin published his classification of American glacial deposits. Chamberlin proposed the name Toronto Formation for the Don and Scarborough beds and placed them in the interval between the Iowan and Wisconsinan glacial stages (Figure 2).The Iowan was for many years considered to be a glacial stage between the Illinoian and Wisconsinan. Later, in 1903, F. Leverett suggested that the Toronto Interglacial beds belonged in the interval between the Illinoian and Iowan glacial stages. This proposal was later accepted by Coleman (1906), who later published a revised Pleistocene stratigraphic classification for southwestern Ontario in 1909 (Figure 2). The classification was based largely on the stratigraphy of the Toronto region. The scheme included: a lowermost Illinoian till, the Toronto Formation interglacial beds, an Iowan till, a second interglacial deposit termed the Clarke interglacial, an upper Wisconsinan till, and finally, lacustrine sand and clay. As stratigraphic classification for the Great Lakes region evolved, the Iowan came to be considered as merely a substage of the Wisconsinan. As a result, Coleman (1932) proposed that the interglacial beds be placed in the Yarmouth interval, prior to the Illinoian (Figure 2). The stratigraphic classification for the Toronto region continued to undergo revision in following years. Putnam *et al.* (1948), suggested in 1948 that the Toronto Formation could be Sangamonian or Yarmouth in age. In 1955, A.K. Watt assigned the formation to the Sangamonian. The classification of the till layers above the Scarborough Formation was addressed by Dreimanis and Terasmae in 1958. These authors assigned the till layers to Early and Late Wisconsinan substages by using evidence based on mineralogical criteria. Terasmae (1960) then revised the stratigraphic classification and applied names to previously unnamed units. However, many of these names are no longer used, with the exception of the lowermost till layer, the York Till, and the till layer above the Scarborough beds, the Sunnybrook Till.

Much of the stratigraphy, as it is presently understood, and the names of lithologic units were outlined by P.F. Karrow in his 1967 report on the Quaternary geology of the Scarborough area (Figure 2). Karrow summarized the stratigraphy as follows. The lowermost till, the York Till, was considered to belong to the Illinoian glacial stage. The Toronto Formation was subdivided into the Don Formation and the Scarborough Formation. The warmer climate Don Formation was assigned to the Sangamonian interglacial. The Don beds were thought to have been deposited near the edge of a lake which stood some 18 m higher than at present. Higher lake levels were likely to have resulted from isostatic uplift of the basin outlet. The colder climate Scarborough Formation was assigned to the Early Wisconsinan. This formation was considered to represent a delta which was deposited in a lake that stood some 45 m higher than at present. This "lake" was caused by the ice damming the lake outlet through the St. Lawrence. The till sheet overlying the Scarborough Formation, the Sunnybrook Till, was also thought to be Early Wisconsinan. Between the Sunnybrook Till and the uppermost till, a complex series of lacustrine, fluvial, and glacial beds were assigned to the Middle Wisconsinan. The fluvial and lacustrine beds were found to contain two intervening till layers. Karrow named the lowermost till layers, the Seminary till, which is the first till lying above the Sunnybrook Till. The second till sheet was termed the Meadowcliffe Till. The fluvial and lacustrine beds were considered to represent one unit and became known as the Thorncliffe Formation. The uppermost till sheet was considered to belong to the Late Wisconsinan. This till had been previously named the Leaside Till by Terasmae (1960), but Karrow (1967) considered that this till should be tentatively correlated with the Halton Till. This correlation was later accepted by workers in the field, and as a result, the Leaside Till became known as the Halton Till.

Karrow updated the stratigraphy in 1974 (Figure 2). He defined a channel fill unit exposed at the Brickworks, located between the Scarborough Formation and Sunnybrook Till. This unit was termed the Pottery Road Formation and was felt to reflect a lowering of lake levels following deposition of the Scarborough beds. The most recent stratigraphic classification of the Toronto and surrounding area was outlined by Karrow in 1984 (Figure 2).

One of the interesting problems investigated during the late 1890s and early 1900s was the length of time represented by the Don and Scarborough Formations, known then as the Toronto interglacial beds. As the scientists of the day had no sophisticated dating techniques available to them, ingenious methods were often applied to provide estimates of the time required for certain beds to be deposited, or for the

CHAMBERLIN (1895)	COLEMAN (1909)	COLEMAN (1932)	KARROW (1967)		KARROW (1974,1984)		FORMATION OR EVENT	LITHOLOGY
					Stage			
Late Deposits	Recent Lacustrine	Recent	Recent		Recent		L. Ontario beaches Alluvium Bog and Swamp Stream Terrace	sand, gravel clay, silt, sand, gravel marl, muck, peat clay, sand, gravel
WISCONSIN	Wisconsin	Wisconsin	WISCONSINAN	Late	WISCONSINAN	Late	Lake Iroquois*	clay, sand, gravel
							Halton Till	silt diamicton
							Sandy Till (?)	sandy diamicton
	Clarke interglacial	Sangamon				Middle	Thorncliffe Fm.	clay rhythmites, sand
		Illinoian					Meadowcliffe Till	silty clay diamicton
							Thorncliffe Fm.	clay rhythmites, sand
							Seminary Till	clayey sand diamicton
				Middle			Thorncliffe Fm.	sand, clay rhythmites
	Iowan					Early	Bloor Member *	clay rhythmites
							Sunnybrook Till *	silty clay diamicton
				Early			Pottery Road Fm. *	sand, gravel
							Scarborough Fm. *	clay, silt, sand organics
Toronto Formation interglacial	Toronto Formation interglacial	Yarmouth	Sangamonian		Sangamonian		Don Fm. *	clay, sand, organics
Iowan	Illinoian	Kansan or Nebraskan (or Jerseyan?)	Illinoian		Illinoian		York Till *	clayey sand diamicton

Figure 2. *A History of Pleistocene Classifications for the Toronto Region. Stars indicate units presently exposed at the Don Valley Brickworks.*

time at which various events occurred. Favourite techniques included varve counting, estimating erosion rates of lake bluffs, erosion rates of buried channels, and estimating the maturity of organic material such as trees which might be found in the sediments. Coleman's paper of 1894 suggested that the Toronto beds represented an interglacial interval when glacial ice had withdrawn quite far from the Toronto area. The following year W. Upham, a prominent American geologist, published a paper which suggested that the interglacial beds were deposited during a minor retreat of the ice which deposited the bounding till layers. Upham argued that the large amount of sediment contained in the Scarborough beds and the cold climate fossils in the beds indicated that the ice front was not very far from Toronto. Coleman disagreed with Upham and felt that the interglacial beds represented a time interval of at least 20 000 years and possibly up to 100 000 years. Coleman produced his time estimates by counting sediment layers, estimating the maturity of fossils, and from examining bedrock channels associated with the interglacial beds. Specifically, Coleman estimated that a river valley cut into the shale bedrock prior to the interglacial would have taken some 25 000 years. Layers of clay in the interglacial beds were considered to represent annual deposition and, thus, some 4300 years were preserved in the interglacial beds. The valleys cut into the top of the Scarborough beds were equated with modern river channel cutting and Coleman estimated that some 50 000 years were needed for this. The interglacial period then was felt to have lasted for a considerable length of time, probably closer to 100 000 rather than 20 000 years.

Coleman's estimates of interglacial time were also challenged by F. Wright (1914) who believed, as did Upham, that the interglacial interval lasted only for a short period of time, perhaps 1 000 years. To account for the short time interval and the presence of warmer climate fossils in the interglacial beds, Wright proposed an interesting hypothesis. Wright suggested that an ice advance from the Keewatin centre deposited the lowermost till. As this ice advanced, it "ploughed up" a large block of Tertiary sediments, perhaps some 100 square miles in size, and deposited it in the Toronto region over the lower till. The Keewatin ice then began to retreat, but almost simultaneously, glacial ice from the Labrador centre advanced into the Toronto area. This ice deposited the Scarborough beds and the overlying till. He suggested by this hypothesis that the warm climate fossils could be accounted for and the succession of interglacial beds could be deposited over a relatively short period of time. Coleman apparently had trouble accepting Wright's ideas and published a rebuttal in 1915. This paper apparently resolved the issue and Coleman's ideas on the subject were accepted.

Through the many works of Coleman, and others, the Brickworks sections were well studied for over 40 years. Much of the early work concentrated on stratigraphy and paleontology. Recent work has focussed primarily on microscopic fossil forms such as pollen, diatoms, and insects. Also, some sedimentological studies have recently been conducted.

Duthie and Mannada Rani (1967) analyzed the Don Formation for diatoms. Their study indicated that the Don beds were likely deposited in a freshwater estuary, with the pH of the water being 7.5 to 9.0. The diatoms also indicated mesotrophic to eutrophic water conditions. The authors suggested fluctuating water levels likely caused changes in the trophic level. Molluscs from the Don Formation were studied by Kalas (1975), Kerr-Lawson (1985), and Karrow and Kerr-Lawson (1986). These studies showed that the molluscs inhabited a medium-sized river system which drained into a lake embayment. Water was always present during deposition of the Don beds; however, shallower water conditions were indicated at the base and top of the formation. Also, cooler climatic conditions were indicated near the top of the succession. Additional studies on cladoceran microfossils (Hann and Karrow 1984) and plant macrofossils (Kerr-Lawson 1985; Karrow and Kerr-Lawson, 1986), have been carried out on the Don beds.

Fossil insect studies of the Don and Scarborough Formations were conducted by Professors A. Morgan, A.V. Morgan, and others, beginning in the 1970s. Little work on insect fauna had been carried out since the studies of Scudder which were conducted during the late 1800s. The results of these studies showed, among other things, that the "extinct" species noted by Scudder in the Scarborough beds were in fact extant forms which presently inhabit areas near the boreal forest-tundra boundary in northern Canada. The insect assemblage from the Scarborough beds indicated that a paleoclimate with a mean annual temperature of -9.5° to 6.5°C existed in the Toronto region during Scarborough time. It was also likely that the climate deteriorated near the end of the Scarborough interval. The fossil insect assemblage from the Don beds indicated a deciduous forest cover existed in the region. The mean annual temperature was likely 4.5° to 7.5°C, or very similar to present day Toronto.

Sedimentological studies of various Toronto Pleistocene deposits have only recently been undertaken. The results of these studies have raised questions regarding previous interpretations, although they themselves remain to be evaluated. Sharpe and Barnett (1985) provided a summary of sedimentological studies for Quaternary deposits of the lower Great Lakes, in which they indicated that the more detailed studies had resulted in an improved understanding of depositional environments and better stratigraphic correlation. However, the studies which included land form control were most useful. The authors also indicated that future studies are needed to provide a better understanding of glacial environments.

The Sunnybrook, Seminary, and Meadowcliffe "tills" were studied by C.H. Eyles (1982) in order to produce a model of deposition. She applied lithofacies coding and the analysis of sedimentary features to the study of the units. This study questioned the need for repeated advance and retreat of glacial ice to produce the "till" units and the lack of evidence for grounded ice. Eyles proposed the "till" units were produced by sediment raining out from the base of floating ice and accumulating on the floor of a lacustrine basin. Lithofacies analysis of the Scarborough Formation was conducted by Kelly and Mar-

tini (1986) to produce a depositional model for the Scarborough delta complex. Kelly and Martini suggested that nearby glacial ice likely influenced the sedimentation patterns found in the formation. Eyles and Clark (1986) reported hummocky cross-stratification in the Don, Thorncliffe, and Lake Iroquois deposits. Eyles and Clarke considered this type of stratification to have formed in shallow water under storm wave conditions. Paleo-water depths and paleo-wave conditions, present at the time of deposition, were estimated by the authors to be as little as 2 m during deposition of the Don Formation at the brickworks site.

There is no doubt that the Don Valley Brickworks have provided a wealth of geological knowledge for more than 100 years. It is difficult to assess what our knowledge of the Pleistocene of the Toronto region would have been, if a curious man had not picked up some clay in 1882 and wondered what value it might have.

This compilation has attempted to assemble all relevant geological literature concerning the Don Valley Brickworks. Most of the references include a short synopsis of the report. In some cases, the original reports have been lost, or the report was unable to be reviewed. In such cases, only the reference is provided. However, it is probable that some references will have been missed. In other cases, readers may feel that pertinent references have been omitted, since we have included only those papers which studied the Don Brickworks sections, or those which studied the same stratigraphic units, but in other locations in the Toronto area.

In the papers which have been annotated by us, the Don Valley Brickworks are referred to by several other names including: the Taylor Brothers Brickwork, the Don Valley Brick Company Pit, and the Don Valley Brickyards. In the annotations, the name referred to in the original document is used.

Acknowledgments

The authors wish to thank a number of people for their contributions to this project: the staff of the Pratt Library, University of Toronto, who provided access to the archival material of Professor A.P. Coleman, and produced photocopies of some of his early papers; Professor P.F. Karrow of the University of Waterloo, who supplied copies of rare field trip guides and reports; and Dr O.L. White, Chief of the Engineering and Terrain Geology Section of the Ontario Geological Survey, and E.V. Sado, Supervisor of the Quaternary Geology Subsection, who provided the opportunity and support for this project to be undertaken.

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1900: On the Geology of the Principal Cities in Eastern Canada; Royal Society of Canada (second series) Proceedings and Transactions, Volume 6, Number 4, p.125-173.

This report deals with the geology of large eastern Canadian cities including Toronto, Montreal, and Quebec City.

In the Toronto area, three distinct layers, or sheets, of till were found to overlie the glaciated surface of the Paleozoic (Georgian Bay) shales. These tills were deposited by land ice which moved in a southwesterly direction from Labrador. Between them a series of interglacial fossiliferous stratified deposits of sand and clay were recognized. The lower intertill deposits were termed the Toronto Formation.

The interglacial deposits exposed at Taylors brickyard have yielded many interesting plant and insect remains. No marine fossil organic remains were found around Toronto which, to the author, suggests fresh water occupied the area at all times.

Antevs, E.

1925: Retreat of the Last Ice-Sheet in Eastern Canada; Geological Survey of Canada Memoir, Volume 146, p.83-94.

This report deals with problems of ice retreat, origin of varves, factors controlling ice recession, and rates of recession.

The amount of time needed for recession of the last ice sheet from the Great Lakes area was based on the number of annual layers of silt and clay deposited in lakes which bordered the ice sheet during retreat.

A comparison of ice retreat rates between North America and Europe was proposed. Although no definite connection could be verified, Antevs suggests a similar pattern of ice retreat occurred between Lake Ontario-Georgian Bay and the Danwash Waslands-Southwest Scandinavia region. This idea was based on the position of moraines and overridden varved clays.

The length of time for the existence of Lake Iroquois was estimated to be approximately 8 000 years (based on methods other than varve counting) and the length of time since ice retreated from the Georgian Bay region was estimated at 13 000 years.

1928: The Last Glaciation; American Geographical Society of New York, Research Series, Volume 17, p.241-243.

This volume attempts to reconstruct the physical conditions at the climax of the last glaciation in eastern North America. Special attention was paid to the peripheral zone of the glaciated are in this region. Especially important in Antevs volume was his work on measurement of varve sections. By studying varve sections it was hoped that yearly records, as well as long term fluctuations, of climate could be identified. It was this principle that led Antevs to try and correlate ice recession between Europe and North America. At Toronto, Antevs suggests that the glacial sequence lying above the Scarborough beds might only represent 1 500 years of deposition.

Varve thickness curves were drawn for the Don Valley and Scarborough sections. It was noted that these curves did not correspond very well. The Don Valley varves were found to be thicker.

Baker, F.C.

1920: The Illinoian Ice Invasion and the Sangamon Interglacial Interval; *in* The Life of the Pleistocene or Glacial Period, Edited by F.C. Baker p.327-333, 342.

This volume presents an account of the glacial and post glacial history for much of the glaciated regions of the United States and Canada. A large section of the book describes the flora and fauna of the known interglacial intervals. Lists of species were provided for many well known sections and stratigraphy of these sections was also described. Age speculation for many of the deposits was also provided.

The Toronto Formation (Don and Scarborough beds) is described in detail. The beds were assigned to the Sangamonian interval. Fossils identified from the interglacial beds provide information on the paleoclimate.

1931: A Restudy of the Interglacial Molluscan Fauna of Toronto, Canada; Illinois Academy of Sciences Transactions, Volume 23, p.358-366.

The Toronto Interglacial beds were found to contain a significant Pleistocene biota. Previously published faunal lists indicate that nearly all of the insect species were extinct as were about half of the mammals. The molluscan fauna was considered to consist of the same species found living in the area today.

The age of the Interglacial beds was not clearly known. The author suggests that they belonged to the Sangamonian interval. It was felt that their exact age could only be determined by undertaking a detailed stratigraphic analysis of the region. By restudying the molluscan fauna and comparing it to other known sites, Baker felt that a better determination of the age of the beds could be made.

The Toronto fauna was suggested to be similar to a post Wisconsinan age assemblage at Chicago. It was proposed that a molluscan migration by way of an interglacial Lake Maumee outlet of a Sangamonian or Yarmouthian Great Lake system may have occurred.

1906: Clay and the Clay Industry of Ontario; Ontario Bureau of Mines; Volume 15, Number 2, 127p.

This report provides a summary of the character, origin, and occurrence of clay deposits in Ontario. The stratigraphic classification of clays includes preglacial shales, four glacial clays and a post-glacial lacustrine clay.

The Don Valley Pressed Brick Company was noted to be one of the oldest and best brick

plants in Canada. The wide variety of clays and shale in this pit allowed the manufacture of many types of brick, including brick for, inside walls, stock brick, terra cotta lumber (a porous brick), fireproofing brick and enamelled brick. This plant was the only one in Ontario producing enamelled brick.

The working section was stated to be 125 feet high, of which 75 feet was shale.

Baker, M.B.
1913: Clay Deposits Near Toronto; XII International Geological Congress, Toronto, Field Guidebook, Volume 6, Number B8 p.50-53.

Professor M.B. Baker led a small party of congress participants to the Don Valley Brick Company to examine the clay deposits and various products which were being produced.

Baker, R.R.
1949: Experimentation in Heavy Mineral Separation in the Don and Upper Illinoian Silt Beds of the Toronto Pleistocene; Unpublished B.Sc. Thesis, University of Toronto.

Banerjee, I.
1973: Sedimentology of Pleistocene Glacial Varves in Ontario, Canada; Geological Survey of Canada Bulletin, Volume 226, Number A.

A number of varve sections in Ontario, including ones at the Don Valley Brickyard, were studied to obtain information on the stratigraphy, sedimentary structures and processes involved in sedimentation of varves. General features of varve sedimentation includes: (1) similarity with flysch-turbidites both in vertical sequence and individual sedimentary structures, (2) areal variation in varves could be explained by the turbidity current mechanism, (3) turbidity currents probably originated on the lower foreset slope of glacial lake delta's, and (4) turbidity currents could be produced by meltwater or sediment slumps.

Varves described from the Don Valley show a gradual coarsening and thickening upwards. In addition, these varves exhibited parallel lamination, grading near the top, and deformed silt clasts. Some small channel cuts and fills were also noted. Photographs of varve sections were included.

Bell, R.
1861: On the Occurrence of Freshwater Shells of our Post Tertiary Deposits; Canadian Naturalist and Geologist, Volume 6, p.42-51.

A number of post-Tertiary aged deposits in Canada were found to contain freshwater shells.

In the Toronto region, one of the numerous terraces found to border the north shore of Lake Ontario, was thought to correspond with a "Lake Ridge" running along the south shore of the lake. This ridge was known to represent a higher water level in Lake Ontario. Also, in the Toronto region specimens of Melania and Unio ellipsis were recovered from a sandy deposit lying above the Silurian(?) bedrock. The exact location of this find was not precisely stated, although, it was noted as being five miles from the asylum, which was located near the University of Toronto. The age of these shells was thought to correspond with the "Lake Ridge" on the southern shore of Lake Ontario.

It was also speculated that when the water level was high in Lake Ontario the sea stood at a high level near Montreal. Bell thought this idea might meet with many objections.

Bensley, B.A.
1913: A Cervalces Antler from the Toronto Interglacial; University of Toronto Studies, Geological Series, Number 8.

A part of a right antler from *Cervalces borealis* was collected by A.P. Coleman in 1909 from the Toronto Interglacial beds. This was a special find, as at the time only a few other specimens had ever been recovered from Pleistocene beds of North America. A similar specimen was previously discovered in Iowa from beds of presumed Aftonian age. The author suggests that the Toronto interglacial beds might also be of Aftonian age.

Berti, A.A.
1975: Paleobotany of Wisconsin Interstadials, Eastern Great Lakes Region, North America; Quaternary Research, Volume 5, p.591-619.

This study investigates the pollen and plant microfossils from a number of Middle Wisconsinan interstadial sites in eastern North America.

At Toronto, the Middle Wisconsinan interglacial Thorncliffe Formation (Upper, Middle, and Lower parts) was studied. The lower Thorncliffe was found to be rich in pollen of *Pinus* (pine), *Picea* (spruce) and herbs largely, *Cyperaceae and Gramineae*. This assemblage suggests a forest-tundra environment. The middle Thorncliffe contained predominantly *Pinus*, *Picea* , some *Betula* (birch), *Quercus* (oak), *Cyperaceae and Gramineae* species. This assemblage also suggests forest-tundra conditions. The upper Thorncliffe was found to contain pollen profiles similar to the lower and middle members.

The author states that at Toronto no changes in the pollen assemblages were coincident with ice advances. Either no vegetational and climatic changes occurred or regional over-representation masked any changes which occurred.

Bigsby, J.J.
1829: A Sketch of the Topography and Geology of Lake Ontario; Philosophical Magazine (Second Series), Volume 5, p.1-15, 81-87.

Blue, A.
1891: Structural Materials; Ontario Bureau of Mines Annual Report, Volume 1, p.104-105.

This report reviews the availability of structural and building materials in Ontario. Blue noted that Ontario was rich in high quality building material.

A short history of the Taylor Brothers Brickyard was included. The Don Valley Pressed Brick Works was opened in 1891 by the Taylor Brothers of Toronto. They first utilized the Ordovician shales to produce red coloured brick. The overlying sediments were noted to be three feet of tough, indurated till, twenty-five feet of sand interbedded with clay and a thick section of Saugeen clay (Sunnybrook Drift) rising to some 140 feet above the river level.

The brickworks was capable of pressing some 44 000 bricks per day and eight kilns on the site could handle an aggregate of 1 100 000 bricks. A total of 55 men were employed at the site.

Brown, R.W.

1942: Supposed Extinct Maples; Science, Volume 96, p.15.

In Coleman's report "The Last Million Years", four interglacial tree species were recorded as being extinct; two maples (*Acer pleistocenicum, A. torontoniensis*), a locust (*Gleditschia donensis*), and a tamarack (*Larix churchbridgensis* . Brown suggests that the two supposed extinct maples were in fact variants of the sycamore, *Plantanus occidentalis*, a species previously identified in the Don Valley. The characteristics of the leaves outlined by Penhallow and Coleman indicated to the author that sycamore rather than maple was being described. It was proposed that the two supposed extinct maples be stricken from the list of extinct species.

Canadian Pleistocene Flora and Fauna

1899: Report of the Committee; British Association for the Advancement of Science, Volume 68, p.522-529.

Numerous shafts were sunk along the Don River and a smaller tributary in an effort to determine whether the warm climate beds of the Don Valley underlay the colder climate beds of Scarborough, or whether these beds were interglacial. Near the tributary the following sequence was found:

Sand	11.5 feet
Sand with boulders	1.0 foot
Sand with some cemented layers	20.0 feet
Gravel with fragments of shell	2.5 feet
Peaty blue clay with sheets of ironstone	30.5 feet
Brown sand and clay	2.5 feet
Bluwash sand and clay	5.0 feet
Gravel with unios	0.5 feet
Brown sand with shells	2.0 feet
Blue sand and clay with unios	6.5 feet
Boulder clay	1.0 foot
Hudson shale (Cambro-Silurian)	30.0 feet

Information from several of these sections showed, among other things, that the Don Valley beds did in fact underlie the colder climate beds, and both the Don Valley beds and the Scarborough beds were deposited between sheets of till.

1900a: Report of the Committee for 1899; British Association for the Advancement of Science, Volume 69, p.411-414.

The sinking of a number of boreholes in the Toronto region, one-third of a mile northeast of the Taylor brothers brickyard excavations, provided information on the Pleistocene stratigraphy and produced a number of insect fragments.

The boreholes penetrated several layers of sands, some gravels, clay, more sand, clay and finally the Hudson shale (Georgian Bay Formation). The work was a continuation of previous digs which were halted due to water infilling the boreholes.

1900b: Report of the Committee for 1900; British Association for the Advancement of Science, Volume 70, p.328-339.

This report provides a summation of previous work by the committee. Two new geologically important sites were reported. The first, an interglacial valley was discovered at a bend in the Don River, where it was found to overlie (Georgian Bay) shale. The second consistes of a series of sand deposits, in western Toronto on Dupont Street, which were considered to be of interglacial age.

The Toronto Formation was noted to consist of warm climate beds (Don beds), conformably overlain by cold climate beds (Scarborough beds). A complex series of Wisconsinan aged layers of tills and stratified sands were found to overlie the Toronto Formation.

Professer D.P. Penhallow provides a detailed list of both fauna and flora identified from the Toronto Formation beds of the Don Valley. Fourteen species of flora were found at Scarborough Heights in the Scarborough beds. Six were identified as trees and the remaining as mosses, equisetor and herbaceous or half-shrubby plants. The plant species were found to be boreal species which suggested a cooler climate. In the Don Valley no less than 38 species were removed from the Don beds. These species indicated a warmer climate than present. Only *Acer plewastocenicum* was thought to be extinct and all others were noted to be representitives in the same region today.

Chamberlin, T.C.

1895: The Classification of American Glacial Deposits; Journal of Geology, Volume 3, p.270-277.

The classification of the glacial deposits of America is presented. Owing to glacial erosion and burial of deposits it was thought that the knowledge of many deposits would remain meager. Representative deposits were used to illustrate this glacial stratigraphy.

The earliest glacial formation in the United States was called the Kansan. Following the Kansan, a notable retreat of ice took place. The interglacial deposits were classed as Aftonian.

The next glacial episode was called the Iowan. Following the Iowan, a major ice retreat occurred.

The Toronto Formation was thought to have been deposited at this time. Fossil evidence indicates that the Toronto beds belonged stratigraphically between the Iowan and overlying Wisconsinan beds. Chamberlin indicates that it was not likely that the beds could be assigned to any earlier interval.

Overlying the interglacial beds were massive and surficially extensive deposits which were assigned to the Wisconsinan Formation. Following deposition of the Wisconsinan Formation a complex series of events occurred before the ice age entirely passed away. Chamberlin suggests that the fossiliferous Toronto Formation beds could be later than the Wisconsinan Formation, and then, they and the overlying till would represent a unique deposit in America.

Chapman, E.J.

1861: Some Notes on Drift Deposits of Western Canada and on the Ancient Extension of the Lake Area of that Region; Canadian Journal (New Series), Volume 6, Number 33, p.221-229.

This paper outlines Chapman's observations and interpretations of the drift covering the area from Kingston, westward to the Saugeen River on Lake Huron. The drift sequence was found to consist of lower laminated, blue or grey clays, sands and gravels containing clay layers and an upper layer of boulders. The upper boulder layer was felt to have been deposited by melting or stranded icebergs. The author noted that Dr Benjamin Workman of Toronto had found fossil specimens of Melania and Unio Ellipsis in the banks of the Don River some 30 feet above lake level. The fossils were felt to have come from the sandy layers of the drift sequence.

Chapman, L.J., and Putnam, D.F.

1951: The Physiography of Southern Ontario, 1st Edition; University of Toronto Press, Toronto, 284p.

This book provides the first comprehensive description of the surface geology, geomorphology and soils of Southern Ontario. The major themes featured were, the role of the underlying bedrock structure in controlling major surface features, the description of landforms composed of unconsolidated sediments and the nature of soils found in the region.

Much of the pre-Wisconsinan glacial information was obtained from exposures in the Don Valley Brickyard. Information for most of the Southern Ontario region was obtained by air photo examination and ground truthing much of the area.

1966: The Physiography of Southern Ontario, 2nd Edition; University of Toronto Press, Toronto, 396p.

The second edition of The Physiography of Southern Ontario provides an update of the very popular first edition. Updated interpretations of several glacial stages, information on till composition and other sediments are included. Regional updates are provided for many areas.

1984: The Physiography of Southern Ontario, 3rd Edition; Ontario Geological Survey Special Volume, Volume 2, 270p. Accompanied by Map P.2715 (coloured), scale 1:600 000.

The third edition of Physiography of Southern Ontario provides, for the first time, a physiographic study of all of Southern Ontario including the Georgian Bay-Ottawa Valley region. Initially the earlier publications were intended mainly as a guide for soil mapping. However, over the years other disciplines including engineering, hydrogeology, and hydrology utilized the book as a starting reference for such diverse projects as pipeline location, aggregate resources, landfill siting, and pollutant seepage. The third edition provides updated statistics and three additional physiographic regions which are: the Georgian Bay fringe, the Algonquin highlands, and the Highway 11 strip.

Charlesworth, J.K.

1957: The Quaternary Era; Edward Arnold Limited, London, p.917-18, 972-77.

The author summarizes the Quaternary era for much of the world through a number of topics. Topics such as ice flow, the number and length of glacial and interglacial intervals, and sea and land levels are discussed.

The Toronto Formation (Don and Scarborough beds) is presented as a classic example of interglacial deposits in North America.

Churcher, C.S., and Karrow, P.F.

1977: Late Pleistocene Muskox (Ovibos) from the Early Wisconsin at Scarborough Bluffs, Ontario, Canada; Canadian Journal of Earth Sciences, Volume 14, p.326-331.

A single right leg bone (fused metacarpals III and IV) of *Ovibos moshatus* was found and identified from the probable stream deposits of the Pottery Road Formation at Scarborough Bluffs. These sediments were correlated with the St. Pierre Interstadial of the St. Lawrence Valley.

Pollen studies were performed on the fossil and compared to similar pollen studies which were conducted on the Pottery Road Formation at the Don Valley Brickyards.

The Pottery Road Formation yields fresh water molluscs and bones of bisons, bear, and moose-elk. This fossil assemblage suggests a northern boreal forest and grassland condition, consistent with the high latitude habitats of recent North American muskox.

The muskox fossil was found in sediments similar to deposits in New York and Montana, that were deposited as the ice sheet advanced.

Clarke, A.H., Jr.

1966: Interglacial *Hendersonia occulta* in Canada; Nautilus, Volume 79, p.137-138.

A Pleistocene mollusc, *Hendersonia occulta*, was discovered in the channel deposits of the Pottery Road Formation exposed in the Don Valley Brick

yard. Discovery of this specimen allowed a considerable extension in habitat beyond the closest known recent or Pleistocene locality. The nearest Pleistocene site was located in Alleghany County, Pennsylvania. This specimen represents the first Quaternary record of a terrestrial archaeogastropod found in Canada.

Coleman, A.P.

1894: Interglacial Fossils From the Don Valley; American Geologist, Volume 13, p.85-95.

Since the mid 1800s numerous fossil species from probable interglacial deposits were recorded in the Toronto area. A most interesting exposure was opened in the Don River Valley one mile north of Gerrard street by the Taylor Brothers Brickworks.

Fossils collected from the site included *Pleurocera sp., Valvata sp., Sphaerium sp.* and many species of Unio. Wood specimens collected from above the lowest till included *Fraxinus quadrangulata, Quercus obtusiloba and Taxus baccata.*

A section description and depositional interpretation is provided by the author. Glacial ice spread a layer of till on a slope toward the hollow of Lake Ontario and then withdrew. A lake formed which stood 40 to 50 feet above present and was likely ice dammed at this stage. Fauna from the Mississippi river watershed were appparently able to invade the Ontario basin although it was not known by which means. The climate in the region was similar to present or even milder. After deposition of the fossiliferous beds the lake rose to at least 140 feet above present level through damming of the eastern outlet by returning glacial ice. Further ice advance covered the stratified clays and sand. When the ice of this epoch retreated, the lake level fell and formed Spencer's Lake Iroquois, 140 feet above the present level of Lake Ontario.

1895: Glacial and Interglacial Deposits Near Toronto (Ontario); Journal of Geology, Volume 3, p.622-645.

The interglacial beds exposed at the Taylor Brothers Brickworks were previously described by Coleman, as were the deposits at Scarborough Heights. Aside from these works little else was known about the drift in the Toronto Region.

This report reviews the nature of glacial deposits at Scarborough Heights, Taylor Brothers Brickworks, the Convict Cutting (located about one mile north of the brickyard), and other minor cuts along the Don River.

The correlation of beds between Scarborough and Taylors brickyard was discussed. The author was uncertain whether the Scarborough beds underlay or rested upon the Don beds. It was hoped that future excavations would solve this problem.

The status of the interglacial beds was also discussed. Upham previously stated that the Toronto beds represented deposition during a minor retreat of the ice sheet. The author on the other hand suggested a major ice retreat occurred and a long interval of time was needed to deposit the beds.

1897: Glacial and Interglacial Deposits at Toronto; Geological Magazine, Volume 4, p.515-516.

This report outlined the stratigraphy of the brick yards section as it was understood. An attempt was made to correlate lithologic units between the Scarborough bluffs and the brickyard. Coleman described three till layers and intervening interglacial deposits. The Scarborough Formation clays were noted to rest upon the warmer climate Don beds. The sequence of Don and Scarborough beds had been uncertain. The main interglacial deposit (Scarborough and Don beds) was correlated with the interval between the Iowan and Wisconsinan glacial advances.

1898: Glacial and Interglacial Deposits at Toronto; British Association for the Advancement of Science, Volume 67, p.650, 651.

Coleman provides an outline of the Pleistocene history and stratigraphy for the Toronto area. Three or more till sheets and a varying number of intertill beds were recognized.

The most important section stated Coleman, was at Taylors brickyard in the Don Valley. The author provides the following section description from the brickpit. The lowest till was found to overlay Cambro-Silurian (Ordovician) shale of Hudson River age. Upon the till rested 18 feet of sand and clay which contained shells, leaves and pieces of wood. The fossils indicated a warmer climate. Above this were stratified sands and clays containing insect and plant remains along with a caribou horn. The fossils indicated a colder climate.

A middle till, on top of these beds, was deeply eroded. Another fossil bearing bed occurred above the middle till and was capped by a third till. The retreat of the last ice sheet was followed by the Iroquois episode which left a well marked beach.

Coleman indicated the main interglacial period probably corresponded to the interval between the Iowan and Wisconsinan glacial advances.

1899: Lake Iroquois and Its Predecessors at Toronto; Geological Society of America Bulletin, Volume 10, p.165-176.

This paper focusses on the problem of marine invasion in the Toronto region during Lake Iroquois time and on the record of former high level lakes.

The finding of numerous shell fragments and other fossils, including caribou and wapiti horns and a mammoth's tooth, in the Iroquois beach deposits, spoke of fresh water deposits and failed to indicate invasion by the sea during glacial or post glacial times in the Great Lakes region.

Coleman outlines evidence for other, earlier high level lakes in the Ontario basin. The records of former water levels in the Ontario basin began with the Toronto Formation. The formation started with the warm climate Don stage which was deposited during the middle of a mild period. At that time lake water was more extensive and reached 50 or 60 feet above present levels. These beds were followed directly, it was thought, by the Scarborough stages, cold, temperate climate beds. During these stages it was probable that a large river drained the upper lakes from Georgian Bay to north of Toronto and formed a delta at Scarborough Heights. Water levels were 145 feet above present at that time.

A series of bodies of water including, Lake Iroquois, formed in the basin during the retreat of the ice.

1901: Glacial and Interglacial Beds Near Toronto; Journal of Geology, Volume 9, p.285-310.

This paper deals in detail with the sequence of Pleistocene deposits preserved in the Toronto area.

Following the retreat of the lowan ice sheet, ice dammed lakes formed. When these lakes drained some erosion took place with water levels falling to lower than present. The Don beds of the Toronto Formation were then laid down during the warm climate portion of the interglacial. Warm climate trees and Mississippi Valley Unios were found in these beds. On top of the warm climate beds were deposited the cold climate Scarboro' peaty clays of the Toronto Formation. In these deltaic deposits, trees, mosses and 70 extinct beetle faunas were identified. Sands deposited on top of the clays, completed the delta formation. Drainage and erosion of deep valleys in the delta deposits then followed.

The advance of the Wisconsinan ice sheet dammed the St. Lawrence and raised water level well above present day. A series of glacial and interglacial beds were deposited. The final retreat of this ice sheet formed Lakes Warren and Iroquois.

1902a: The Duration of the Toronto Interglacial Period; American Geologist, Volume 29, p.71-79.

Coleman discussed the Toronto interglacial beds and the amount of time required for the processes which took place between the bounding ice advances. Deposition of the beds was considered to require a minimum of 1 300 years and 2 500 years were thought to be needed for development of the valleys which incised the top of the beds. Coleman stated that it was likely that the time interval was actually more than double the minimum estimates. During the interglacial time the author proposed that the ice sheet had disappeared almost completely in Canada. Mr. Warren Upham, on the other hand, suggested that the ice sheet never withdrew very far from Toronto.

1902b: The Relation of Changes of Level to Interglacial Periods; Geological Magazine, Volume 9, p.59-62.

This paper outlines Coleman's views on the causes of the Toronto interglacial period and the related shifts in lake levels. The author noted that prior to deposition of the Don beds the water level was likely similar to present. The water level rose to 60 feet above Lake Ontario after the Don beds and then to 152 feet or more during deposition of the Scarborough beds. Water level subsequently fell to a point much below lake level. Coleman proposes that the best explanation for fluctuating water levels was epeirogenic uplift toward the northeast. He pointed out that as the ice sheet melted the basin outlet would rise causing water to pond back to a height of more than 150 feet above present level. At the maximum height of uplift, Labrador was felt to stand 3 000 feet higher than today. Coleman suggests that once Labrador had risen to such a high level snow might have started to accumulate in the highland areas. Substantial buildup of snow could possibly have triggered a subsequent glacial period.

1904: Glacial Lakes and Pleistocene Changes in the St. Lawrence Valley; 8th International Geographic Congress, p.480-486.

A succession of great lakes followed the front of the retreating Wisconsinan ice sheet. The beach lines of these lakes were found to rise toward the northeast, which indicated differential uplift of the continent in that direction.

A few geologists believed that the bodies of water which formed the raised beaches were arms of the sea and each shore line was formed at sea level.

The area was invaded by ice more than once and long continued interglacial periods separated the glacial episodes. The best recorded interglacial period in America was the Toronto Formation, which included the Don and Scarborough beds. These deposits were formed by the Laurentian River which drained the valleys of the upper Great Lakes. The exact chronological position of the Toronto interglacial was uncertain but was thought to occupy the interval between the lowan and the Wisconsinan ice sheets, although some people placed it just after the Illinoian ice age.

The Toronto deposits began with stratified sand and gravel containing wood and Unios at a point 40 feet below lake level. This indicated that the water level in the basin was lower than at present. Upwarping of the basin outlet caused water level to rise until it was 60 feet above present. A large delta up to 20 miles wide was deposited. The fossil record from the Scarborough beds indicated a much cooler climate.

The water in the basin then drained, probably as a result of ice accumulation in Labrador, which caused a downwarping of the basin outlet. An ice advance deposited till over the delta surface. Above the boulder clay, stratified clay and sand

were deposited, which indicated ice recession and formation of a glacial lake.

Above this section three other sheets of till, separated by stratified sand and clay, indicated three advances and retreats of glacial ice had occurred. One of the stratified sand beds was extensive and extended 50 miles northeast to Coburg. A lake comparable to Lake Iroquois must have existed. The interglacial period contained episodes like those which took place since the retreat of the last Wisconsinan ice sheet.

1906: Interglacial Periods in Canada; X International Geological Congress, Compte Rendu, Mexico, p.5-26.

The author described interglacial deposits from across Canada. Extensive interglacial beds of at least three ages were thought to occur in Canada. The oldest occurred in British Columbia and Alberta with two later ones found between the Illinoian and Iowan, and the Iowan and Wisconsinan in southern and northern Ontario. The best known interglacial occurred at Toronto. This interglacial (Don and Scarborough Formations) was thought to have lasted some 20 000 to 100 000 years, based on the fossil record and on the amount of sediment deposited. Interglacial beds thought to be of similar age were located on Lake Erie to the southwest and in Hudson Bay lowlands lignite deposits.

The author thought that during at least one interglacial, eastern North America was free of glacial ice. The complete series of ice ages and interglacial periods was thought to have lasted several hundred thousand years.

Past workers used alpine glaciers as models for the conditions of continental ice sheets. Coleman suggested abandoning this concept as alpine glaciers responded much differently to climatic influences.

1909: Classification and Nomenclature of Ontario Drift; Ontario Bureau of Mines, Volume 18, Number 1, p.294-297.

The drift deposits of Ontario were found to be difficult to correlate and classify. The first serious classification, put forth by the Geological Survey of Canada, consisted of from oldest to youngest: a lowermost boulder clay, Erie clay, Saugeen fresh water sand and clay, Artemesia gravel, Algoma sand and finally modern alluvium. This classification proved to be incomplete and inaccurate. Work at the Scarborough bluffs by the author provided the following classification for the Toronto region and Western Ontario.

Lacustrine - Nippissing

recent deposits - Algonquin, Iroquois, Warren - gravels

Glacial - Wisconsinan Moraines, Wisconsinan Till

Interglacial - Clarke Interglacial sands and clay

Glacial - Iowan Till

Interglacial - Toronto Formation (Scarborough and Don beds)

Glacial - Illinoian Till

1910: Changes in Climate in Southern and Western Ontario since the Maximum of the Last Glaciation; XI International Geological Congress, Stockholm, Sweden, p.385-387.

Climatic change in southern Ontario during the Pleistocene epoch was indicated by the alternation of glacial and interglacial deposits at Toronto. The Toronto Formation (Don and Scarborough Formations) contained a lower forest growth which indicated temperatures somewhat warmer than at present, followed by a climate somewhat cooler than now. These beds were followed by glacial conditions.

The evidence for climatic variations since the maximum of the last ice age, that of the Wisconsinan ice sheet, was much harder to interpret. However, it was stated that there was a general rise in temperature from Arctic conditions during the maximum glaciation to a cold temperate stage during the existence of Lakes Nippissing and Algonquin. During the existence of the Nippissing Great Lakes and marine invasion (Champlain Sea) the climate was similar to present day. A warmer climate than present probably existed during the early history of Lake Ontario.

1913a: Glacial Phenomena of Toronto and Vicinity; Ontario Bureau of Mines, Volume 22, Number 1, p.238-255.

The Toronto region was divided into two physiographic parts, a terrace, formed by Lake Ontario, sloping gently upward from Lake Ontario and a higher upland, formed of rolling hills. The region was incised by the river valleys of the Don and Humber Rivers. Excellent exposures of Pleistocene deposits were revealed.

The surface of the bedrock beneath the city had a high relief before the first Pleistocene ice sheet moved across the area. A large wide valley some 200 feet deep was carved by a river which flowed south from the Georgian Bay region. Immediately overlying the shale a sheet of till was identified. In some places, four younger till sheets each separated by intertill beds of stratified gravel sand and clay were noted.

The earliest and most important interglacial included 185 feet of delta deposits (Don and Scarborough beds). Later ones were usually 30 to 40 feet thick and probably represented short recession of ice.

The lowest interglacial deposits, the Don beds, produced thirty-two tree species, forty-one species of shellfish plus undetermined beetles and cypids. Identified mammal bones, included bear, bison, deer similar to Virninias red deer, and a deer related to caribou.

1913b: Geology of the Toronto Region; *in* The Natural History of the Toronto Region, Ontario, Canada, Edited by J.H. Faull p.51-81.

Within a radius of one hundred miles from Toronto geological formations from the Archaean to the Pleistocene could be studied. The immediate Toronto area included some of the most important Pleistocene sections in North America. A record of the last geological periods, including action by ice sheets, was preserved.

The region was noted to have low relief. Although the variatons in elevation were small the surface features were found to include lacustrine plains, rolling uplands and an escarpment.

Vast intervals of time existed between the Archaean and Paleozoic and the end of the Pliocene. It was probable that during both intervals the region was a land surface undergoing denudation. Lakes covered the region in recent times due to Pleistocene shiftings of level or to the damming of valleys by ice masses.

1913c: Don Valley and Scarboro' Heights; XII International Geological Congress, Toronto, Field Guide Book, Volume 6, Number B2 p.5-34.

The interglacial beds at Toronto were noted to be best exposed at the Don Valley Brickworks and Scarborough Heights. This excursion to the Don Valley Brickyard and Scarborough Heights was attended by 65 people. The participants were shown the relationship of the interglacial beds with the boulder clays (tills) above and below. Shells and wood fragments were collected from the Don beds.

High water level in Lake Ontario prevented participants from walking along the base of the bluffs, consequently only the distinct Dutch Church section was observed from the crest of the bluffs.

1914a: Length and Character of the Earliest Interglacial Beds: Abstract and Discussion; Geological Society of America Bulletin, Volume 25, Number 1, p.71.

The earliest interglacial beds at Toronto were thought to correspond in age to deposits in New York and on both sides of Lake Erie. They were also thought to correspond with lignite deposits in the Hudson Bay Lowlands some 400 miles north of Toronto. The author stated, based on fossil evidence, that the interglacial beds probably belonged to the Aftonian interglacial. It was also noted that most of the mammals of the Toronto Formation were thought to be extinct as were the trees and 70 of the 72 identified beetle species.

Interglacial deposits at Toronto were found to be underlain by river valleys that were carved before deposition of the beds. Following deposition the beds were deeply incised by stream channels. The author indicated that the time span for carving of the valleys plus deposition of the interglacial beds was some 75 000 to 100 000 years.

1914b: An Estimate of Postglacial and Interglacial Time in North America; XII International Geological Congress, Toronto, Canada p.435-449.

Various attempts were made to estimate the length of time since the retreat of the last ice sheet. In Europe DeGeer used terminal moraines and marine clays to produce an estimate of 12 000 years. Many North American workers used the recession of Niagara Falls to produce estimates of 7 000 to 40 000 years.

Coleman used erosion rates of the Scarborough Bluffs and the value of sediment deposited on the Toronto Harbour bar to produce estimates of time since retreat. Coleman derived estimates of 8 000 years to build the Toronto Harbour bar and nearly 9 000 years to erode the Scarborough Bluffs to their present position. Adding in a similar time span for the existence of Lake Iroquois gave an estimate of 24 000 to 27 000 years for post-glacial time.

Coleman also estimated the time span for the Toronto interglacial by using estimates of the time needed to cut channels in the bedrock (8 000 years), fossil trees in the Don beds and the length of time needed for maturity (1 000 years), and counting layers in the Scarborough beds (3 300 years). After deposition of the Scarborough beds the cutting of three channels into the strata, as a result of falling lake levels, was thought to have taken 50 000 years. All things considered the Toronto Interglacial probably lasted 100 000 years or more.

1915: Length and Character of the Earliest Interglacial Period; Geological Society Of America Bulletin, Volume 26, p.243-254.

The Toronto Formation contained two divisions: a lower one, known as the Don stage, and an upper one, the Scarboro stage. There was no apparent unconformity between the two.

The lowermost till (York Till) was deposited by an ice sheet which advanced southwest or west from the Labrador centre. At one point along the Don River both the till and shale beneath were cut away by a small interglacial river. In this valley, shingle gravel was deposited along with fossils indicative of a warmer climate. The total thickness of beds in this section was 40 to 45 feet.

At the Don Valley Brickyard, tree trunks up to 15 feet long and still retaining branches were found flattened into the surface of the boulder clay.

The Don beds were deposited in a lake whose level stood 50 to 60 feet above present. Lake level was thought to have risen as a result of uplifting of the Lake Ontario outlet.

The Scarborough beds were found to contain little lime and thus were derived from highly weathered material that originated from north of Toronto. The fossils derived from the Scarboro beds included 72 species of beetles of which only two were thought to be still living. The beetles were thought to have come from a more northerly climate possibly like that of the northern part of the Gulf of St. Lawrence or southern Labrador.

Professor G.F. Wright did not agree with an interglacial origin for the Toronto Formation. Wright suggested that the warm climate Don beds consisted of Tertiary materials. Deposition of the Don beds occurred when readvancing ice "ploughed up" the Tertiary sediments and deposited them without much disturbance in their present position. Coleman suggested that similar interglacial beds were found in the river valleys of the James Bay slope. He argued that if the James Bay interglacial was equivalent to the Toronto interglacial, an ice sheet could not have existed at that time as no ice sheet exists today. The length of time for the interglacial must have been 75 000 and 100 000 years.

1922: Glacial and Postglacial Lakes in Ontario; University of Toronto Studies, Biological Series, Volume 21.

In collaboration with the University of Toronto department of biology, a study of the economic fishery problems of Ontario was undertaken. The existence and distribution of fishes and other aquatic organisms was stated to depend upon the succession of events which occurred in the lakes in the past. Coleman provides a history of the Great Lakes, through preglacial and glacial times. References to climatic change and fossil assemblages were outlined for various glacial and post glacial lakes. One of the best known intervals belonged to the Toronto interglacial beds. From the Don beds many faunal remains were collected, including bones of a fish identified as a catfish.

1925: The Pleistocene Rocks of the Toronto Region (Ontario); British Association for the Advancement of Science, Volume 92, p.379.

Most of the surface of the Toronto region was stated to consist of Pleistocene drift sediments. The stratigraphy of the region was outlined and included a till resting on Ordovician shale, a series of interglacial beds 185 feet thick, four additional sheets of till with interstratified clay and sand followed by deposits of Lake Iroquois.

The author indicated that the interglacial Toronto Formation had produced nearly 200 species of plants and animals, including trees indicating a warmer climate.

Good exposures of the interglacial beds were found at Scarborough Heights and in the Don Valley. The Toronto Formation was the most extensive and important interglacial deposit in America according to Coleman.

1926: Ice Ages, Recent and Ancient; MacMillan Press, New York, p.23-28,235.

This volume outlines the distribution of the Pleistocene glaciers and intervening interglacial periods. The relatively well known Pleistocene glaciations were compared to the work of modern glaciers so that a comparison could be made regarding modes of work and glacial deposits. By studying modern glaciers and Pleistocene glacial deposits an examination of older glaciations was presented.

The Toronto Interglacial (Don and Scarborough beds) was presented as a classic example of an interglacial deposit.

1929: Long Range Correlation of Varves; Journal of Geology, Volume 37, Number 8, p.783-789.

De Geer worked out an accurate chronology for the retreat of ice in Sweden by studying varves in northern Europe. He then came to North America seeking to correlate varves on this side of the Atlantic with those of Europe. He reasoned that the recession of the ice sheet in North America might be expected to follow a similar course to that in Europe.

A series of 400 varves (Bloor member) at Toronto was found to correspond with the varves of Sweden to an extent of some eighty percent. De Geer deduced from his North American study that Niagara Falls began some 9 500 years ago.

The major problem with De Geer's trans-Atlantic correlation was that the Toronto varves were of a much older age than those in Sweden. Coleman pointed out that great caution was needed in correlating varves from widely distant points.

1932: The Pleistocene of the Toronto Region; Ontario Department of Mines, Volume 41, Number 7.

This report summarizes more than forty years of work conducted by the author on the Pleistocene deposits of Toronto. Descriptions of many excavations and sections, including the Don Valley Brickyard, Scarborough Bluffs and Sun Valley Brickyard provided detailed accounts of stratigraphy and of the fossil record. The stratigraphy was classified as follows:

most recent till - Wisconsinan

interglacial sand - Sangamonian

middle complex of tills and varves - Illinoian

interglacial Toronto beds (Scarborough, Don) - Yarmouthian

lowest till - Kansan or Nebraskan (or Jerseyan?)

As well, descriptions of Lake Iroquois deposits are provided. Finally the author provides an account of the climatic regimes present for the various deposits and an estimation of the time frame needed to form the succession. A map of the Toronto Pleistocene geology was included.

1936: Lake Iroquois; Ontario Department of Mines, Volume 45, Number 7, p.1-36.

This report deals with the Pleistocene formations, in particular the Iroquois Beach deposits, of the Toronto Region. The beach was traced from Niagara to the Hastings-Rice Lake area and into New York State.

At Toronto, the Iroquois shore was cut by the Humber and the Don Rivers whose valleys were flooded and blocked off by storm built westward bars. The Don Bar was compared to the present day Toronto Island, as both were felt to be about the same size and shape. Evidence in the Don

Valley brickyard indicated that early Lake Iroquois stood 70 feet below its later stages. Leveled on the Humber bar and east of Scarborough, the beach was found to rise 2 feet per mile in distance. Lake Iroquois started about 25 000 years ago and lasted until 16 000 years ago. Lake Ontario formed eight or nine thousand years ago. Many of the Iroquois deposits were tapped for their clay deposits to produce bricks.

1941: The Last Million Years; University of Toronto Press, Toronto, 216p.

The glacial history of the Great Lakes (Erie and Ontario) is outlined. Often only the latest Wisconsinan tills were preserved. Evidence of earlier tills was sometimes found in ravines.

Along the shores of Lake Ontario, from Hamilton to Toronto, two tills with varves, or beds of sand, between them were found. At Toronto the drift thickened with three till sheets separated by stratified clay and sand. All three of the tills came from a glacial centre in Labrador rather than a Keewatin ice centre.

Between the lower two sheets of till, interglacial beds of the Toronto Formation were found. The lower part of this formation was deposited under conditions warmer than present. A lake 60 feet deeper than Lake Ontario existed at that time into which emptied a river flowing from the north.

There was no visible break between the Don stage and the stratified clays of the overlying Scarborough beds. The author suggested that the Scarborough beds represented a delta some twenty-five miles wide. The lake level rose some 90 feet above the level present during the Don stage. The rise in level was attributed to uplifting of the outlet.

Following deposition of the Scarborough beds, the lake level dropped some 165 feet likely due to lowering of the outlet. Valleys were cut into the interglacial beds and later filled with sand, gravel, and clay. Fossils from these beds were mainly warm climate forms similar to those from the Don beds.

The Toronto interglacial period began with a warm climate, followed by a cooler stage (Scarborough), and ended with a warm climate. This sequence seemed to be in reverse to what would be expected in an interglacial. Alternatively the sequence may have represented two interglacials with a cool period between them which corresponded to a glacial period in which the ice sheet did not reach the area. The ice advance which deposited the second till disturbed the underlying interglacial beds at Toronto very little. The ice halted in the Ontario basin near Toronto for some 1 500 years, advancing and retreating and left three beds of till separated by two series of varves. The ice which brought this till must have been thin to have been halted by the Scarborough delta barrier for so long.

The third till sheet was comparatively soft and sandy. It formed the gently rolling surface north of the Iroquois beach.

Crawford, A.M., Lau, K.C., and Horvath, R.G.
1978: Sunnybrook Till-Field and Laboratory Investigation; Department of Geology, University of Toronto, 24p.

Crossman, E.J., and Harington, C.R.
1970: Pleistocene Pike, *Esox lucius* and *Esox sp.* From the Yukon Territory and Ontario; Canadian Journal of Earth Sciences, Volume 7, p.1130-1138 Pleistocene.

Two Esox specimens were found along the Old Crow River in the Yukon, however a tooth from an older specimen was unearthed in 1968 in the Don Valley Brickyards. It was found in the Don Formation (Sangamonian in age), 35 cm above the Illinoian York Till. The Yukon specimens were of probable Wisconsinan age.

The temperature during deposition of the Don Formation was estimated to have been 5°F warmer than present. Radiocarbon dating of a piece of wood found in the same formation dated to 46 000 years ago. This date coincided with the last interglacial.

The presence of *E. lucius* was suggested to indicate a warm water well colonized, lacustrine habitat. There was no significant difference between the fossil tooth and recent pike teeth. The tooth size indicated an individual of approximately 24 pounds.

Dawson, Sir W., and Penhallow, D.P.
1890: On the Pleistocene Flora of Canada; Geological Society of America Bulletin, Volume 1, p.311-334.

The Pleistocene deposits of Canada were thought to consist of three principal members, a till, stratified and sandy clays (the Leda clays and sands), and coarse clays and gravels termed the Saxicava deposits or upper boulder formation.

Fossil plants appeared in these deposits in many areas of Canada. Interesting deposits along Lake Ontario were described by G.J. Hinde in 1877. Later J. Townsend of Toronto found leaves, wood fragments and shells of *Melania* and *Cyclas* in excavations along the Don River. The collected specimens were sent to the Peter Redpath Museum at McGill University in Montreal. One of the excavations described by Townsend became the Don Valley Brickworks. The lower part of this section (Don beds) produced fresh water shells, wood and a maple leaf which was identified by Penhallow. Other species identified from Don River sections included *Asimina trilobita*, *Ulmus racemosa*, and *Taxus baccata*.

De Geer, G.
1926: On the Solar Curve; Geografisca Annaler, Volume 8, p.253-283.

During the climatic epoch of the last ice age, the solar radiation was almost exclusively used to melt away the vast accumulation of ice. As ice melted, it no doubt carried sediment which would later be deposited. The author suggests that if accurate measurements of the annual amount of

the finest materials deposited could be obtained, a solar curve could be constructed.

By studying varve and moraine deposits, De Geer postulates that much similarity in deglaciation existed between Sweden and North America. Many sections exhibiting varves were visited in North America, including the Don Valley Brickworks. The varves, measured at the brickyards, were thought to have been deposited in a marginal ice lake which existed along an ice border that stretched across western Canada and into the eastern United States.

Department of Planning and Development, Conservation Branch, Ontario
1950: Don Valley Conservation Report.

This report examines the historical and conservation efforts that were being carried out in the Don River watershed. The document examines the watershed from a number of perspectives, namely land use, forestry, water resources, wildlife, recreation, and general which includes descriptions of physiography and geology. It is emphasized that much of the knowledge of the Pleistocene geology for the Toronto region was obtained by A.P. Coleman from his studies at the Don Valley Brickworks.

A number of recommendations regarding the aforementioned topics are included. In general, the recommendations encouraged the preservation of greenspace, historical buildings and sites, and urged the construction of recreational facilities.

Derry, D.R.
1933: Heavy Minerals in the Pleistocene Beds of the Don Valley, Toronto, Ontario; Journal of Sedimentary Petrology, Volume 3, Number 3, p.113-118.

A study of the heavy minerals from the glacial and interglacial deposits exposed at the Don Valley Brickyard was conducted. The mineral occurrences were found to be very similar for both glacial and interglacial beds. However, when individual minerals were plotted as a percentage of the total heavy minerals, rather sharp distinctions between glacial and interglacial deposits were noted. Very little variation could be found between the various interglacial beds.

The majority of the heavy minerals for the whole succession were derived from igneous and metamorphic rocks of the pre-Cambrian shield. The materials of the interglacial beds were thought to be derived from the glaciers and icebergs themselves or from older tills. The Paleozoic sediments which underlie the region contributed little sediment to the interglacial beds.

Devaney, J.R., Fralick, P.W., Eyles, C.H., and Eyles, N.
1984: Pleistocene Sand-Clay Couplets of the Don Valley Brickyards: Varves or Discrete Event Turbidites?; Geological Association of Canada, Mineralogical Association of Canada, Program with Abstracts, Volume 9, p.57.

Rhythmically bedded sand-clay couplets are examined at the Don Valley Brickyard to provide information on their mode(s) of deposition. Three types of couplets are noted. They are described as follows: type 1 consisted of complex units having a coarse base which graded into a clay rich top by development of an interbedded sand-clay zone; type 2 were simple units with a coarse base either sharply or gradationally overlain by a clay rich unit; type 3 couplets contained abundant silt and fine grained sand chips in the coarse lower unit.

Formation of these couplets, "varves", was thought to be related to bank overspills of turbidity events. These events created dilute sediment clouds which spread over interchannel areas.

Dreimanis, A.
1960: Pre-Classical Wisconsin in the Eastern Portion of the Great Lakes Region, North America; International Geological Congress, Report of the Twenty-First Session, Norden, Part 4, p.108-119.

Early Wisconsinan tills (pre-classical Wisconsinan or post Sangamonian) of the Great Lakes region were found to contain different matrix content of garnet and carbonate when compared to classical Wisconsinan tills. This suggested that the principal centres of glacial outflow were further east during the Early Wisconsinan. The author suggests that this hypothesis could also explain the absence of Early Wisconsinan drift in the western Great Lakes region.

At Toronto, the Early Wisconsinan till was underlain by cool climate Scarborough beds. This lower till contained considerably more purple garnet and dolomite than the overlying two main Wisconsinan tills. It was suggested that the Early Wisconsinan glacial movement traversed the dolomitic Paleozoics and the purple garnet Precambrian, north of Montreal and in the southeastern Adirondacks. These areas were further east than mineral indicators of later glaciations.

1961: Tills of Southern Ontario; *in* Soils in Canada, Royal Society of Canada Special Publications, Edited by R.F. Legget, Volume 3, p.80-96.

This paper examines a number of tills from Southern Ontario to determine 1) how the bedrock and non-consolidated depos ; influenced till composition and texture, 2) how different till layers and ice lobes could be differentiated on the basis of lithology and texture, and 3) how application of these techniques could be used to reconstruct the Pleistocene of Ontario.

At Toronto, the Illinoian Till was noted to be shale and clay rich, reflecting the influence of the underlying Dundas shale bedrock. Other Wisconsinan tills also showed the effects of the regional bedrock.

1969: Late Pleistocene Lakes in the Ontario and the Erie Basins; *in* Proceedings of the Twelfth Conference on Great Lakes Research, Edited by D.V. Anderson and S.S. Seddon, International Association for Great Lakes Research, p.170-180.

No solid information was available for the pre-Illinoian or for the Illinoian glacial stage, so conclusions could not be drawn on the proglacial lakes in the Ontario or Erie basins for that time.

The author stated that lake level in the Ontario basin rose due to isostatic uplift of the St. Lawrence outlet during the Sangamonian. Dreimanis suggested, as well, that the Erie basin was host to a contemporary lake. Alterations of the lake levels caused by frequent ice movement occurred in both basins during the Wisconsinan.

Several high lake-level and low lake-level periods were known for both basins; however, absolute dating, exact boundary positions and glacial margin positions were still uncertain.

Dreimanis, A., and Goldthwaite, R.P.
1973: Wisconsin Glaciation in the Huron, Erie and Ontario Lobes; Geological Society of America Memoir, Volume 136, p.71-106.

This report detailed the Wisconsinan aged glacial events of North America.

During the Early Wisconsinan in southern Ontario, ice blocked the Ontario basin and created Lake Scarborough within which a large delta formed. This deposit at Toronto was named the Scarborough Formation. The succeeding interglacial (St. Pierre interstade) was represented by deep erosional valleys which cut into the Scarborough and underlying Don Formation.

Middle Wisconsinan deposits were represented by the Thorncliffe Formation, the Seminary and the Meadowcliffe Tills found at the Scarborough Bluffs in Toronto.

Wentworth, Halton and Leaside tills were deposited in and around Toronto during the advances and retreats of the Erie Ontario lobe of the Late Wisconsinan glacier.

Dreimanis, A., and Karrow, P.F.
1965: Southern Ontario; Guidebook for Field Conference G, Great Lakes-Ohio River Valley, VII Inqua Congress, Nebraska Academy of Science, p.90-110.

This field guide outlines the glacial history for those areas in Southern Ontario affected mainly by the Ontario-Erie glacial lobes. Various glacial and interglacial or interstadial deposits were examined. In the Toronto area, fieldstops were made at Woodbridge, Scarborough Bluffs, and the Don Valley Brickyard.

At the Don Brickyard, the channel fill unit (Pottery Road Formation) which cut through the Scarborough and Don beds, was noted to contain boulders and clay lumps at its base. It was suggested that the material may have been derived from a till sheet which overlay the Scarborough beds and was subsequently eroded.

1972: Glacial History of the Great Lakes-St. Lawrence Region, the Classification of the Wisconsin(an) Stage and Its Correlatives; XXIV International Geological Congress (Montreal), Volume 12, p.5-15.

Early, Middle and Late appeared as natural substages of the Wisconsinan Stage, based upon glacial advances and retreats in the Great Lakes-St. Lawrence region. More detailed classifications were thought to be possible based on proglacial lake levels which depended on ice sheet positions that dammed their outlets.

Radiocarbon dates, till analysis, and climatic interpretation were among the gathered information, which allowed subdivision of the substages into several stadials, interstadials, phases, and intervals. These compared well with general northern hemisphere glacial history. Much of the information on the earlier stages was collected from the Don Valley Brickyards and Scarborough Bluffs.

Dreimanis, A., and Terasmae, J.
1958: Stratigraphy of Wisconsin Glacial Deposits of Toronto Area, Ontario; Geological Association of Canada Proceedings, Volume 10, p.119-136.

This report studies the post Sangamonian deposits of the Toronto area through the use of lithologic and palynologic criteria. The following series of events for the Wisconsinan were suggested. An Early Wisconsinan glaciation with regional ice flow via the St. Lawrence Valley into the Ontario basin first occurred. A long cool interstadial interval followed and was thought to correlate with the Port Talbot interval in the Lake Erie region. Vegetation was thought to consist of evergreen forests. The main Wisconsinan glaciation followed with the main glacial flow entering Lake Ontario west of the St. Lawrence Lowlands. The middle till was deposited at this time. The Ontario lobe retreated to the east during an interval probably correlative with the Two Creeks. A proglacial lake developed in front of the glacier in the Ontario basin. A glacial readvance possibly occurred during the Valders substage, deposited the upper Wisconsinan till, and formed drumlins.

Duthie, H.C., and Mannada Rani, R.G.
1967: Diatom Assemblages from Pleistocene Interglacial Beds at Toronto, Ontario; Canadian Journal of Botany, Volume 45, p.2249-2261.

The interglacial Don Formation was sampled for diatoms at the Don Valley Brickyard. One sample was collected from the lower part of the Scarborough Formation at the same location. Over 200 species of diatoms were identified from 34 samples. The overall assemblage indicated deposition occurred in a fresh water estuary having a pH of 7.5 to 9.0. Mesotrophic to eutrophic water conditions were suggested.

The diatom flora was temperate and not unlike the assemblages found in the vicinity of the lower Great Lakes at present. It appeared that the

character of the estuary or river changed from sample to sample. Some of the samples were deposited in slow moving water with weedy sections while others were deposited in more rapidly moving waters. The authors suggest that such variation may have been caused by fluctuating water levels or by channel switching.

The sample from the Scarborough beds suggested a decreased trophic level in the lake. A change to a cooling climate was not recognized as diatoms were stated to be poor climatic indicators.

Eyles, C.H.
1982: The Sedimentology of the Early and Middle Wisconsin Deposits at Scarborough Bluffs, Ontario; Unpublished M.Sc. Thesis, University of Toronto.

The glacial model for Eastern North America at this time, stated that during the Wisconsin three fine-grained diamict units (Sunnybrook, Seminary and Meadowcliffe Tills) were produced through three separate grounded ice incursions, separated by interstadial lakes. This succession was seen at Scarborough Bluffs.

New lithofacies codes indicated that these 'Tills' are really the result of sedimentation in enlarged lakes subject to high inputs of suspended sediments, with a variable clast component, rafted in by floating ice. Three lithofacies types were found: massive diamicts, resedimented facies and current reworked facies. The author suggests that these sediments are not tills, but do form diamict assemblages.

The sandy lithofacies separating the diamict assemblages were largely of subaqueous origin and record numerous delta progradations over diamicts accumulating as stony lake bottom muds.

Eyles stated that major lithofacies breaks within the Scarborough Bluffs succession reflect gross changes in ice distribution in the basin rather than detailing movements of an ice front.

Eyles, C.H., Eyles, N., and Day, T.E.
1983: Sedimentologic and Paleomagnetic Characteristics of Glaciolacustrine Diamict Assemblages at Scarborough Bluffs, Ontario, Canada: *in* Tills and Related Sediments, Edited by E.B. Evenson and C.H. Schluchter, and A.A. Balkema, p.23-45.

This report suggests an approach to describing and interpreting sequences on the basis of lithofacies descriptions using lithofacies codes, analysis of stratigraphic sequences and remanent magnetism. The authors stated that the multiple 'tills' found at the Scarborough Bluffs were glaciolacustrine diamicts formed by pelagic rain-out and ice rafting.

It was further suggested that glacial deposits below current lake level at the bluffs may be related to the Sangamon interglacial Don Formation and possible Illinoian till found in the Don Valley.

Eyles, N.
1984: The Don Valley Brickyard to Close; Geolog, Volume 13, Number 4, p.42-43.

During the summer of 1984 it was announced that the Don Valley Brickyards in Toronto would be closed. This area exposed the world famous "Toronto Interglacial Beds" of Sangamonian age, which were known to contain a record of the cooling trend at the end of the last interglacial.

Although the brickworks had been extensively studied, many of the previous reports were now dated, according to the author. New methods and developments in sedimentology, radiometric dating, palynology, and paleoecolgy could add significant information.

Eyles proposed that through the help of the Ontario Heritage Foundation and the hundreds of Canadian and worldwide geologists that have visited the site, the Brickyards could be preserved for possible further studies. As well it was suggested that 'A.P. Coleman Park' could be developed to honour the pioneering geologist of Canadian glacial studies.

1986: Update: The A.P. Coleman Geological Heritage Site at the Don Valley Brickyard; Geolog, Volume 15, Number 2, p.38-39.

The Don Valley Brickyard was, at the time of writing, undergoing a battle between the owners, who wished to develop the site for residential use, and public groups who wanted to preserve the site for a heritage and educational centre. The brickworks site was stated to represent an important reminder of both the industrial and geological past of Toronto.

The importance of the site was first recognized by Professor A.P. Coleman in the late 1800s. His interest in this site and others around Toronto produced many noteworthy articles over a span of five decades. Eyles proposed that it would seem appropriate to name any heritage or educational centre which may be developed after Dr. Coleman.

Eyles, N., Clark, B.M., Kaye, B.C., Howard, K.W.F., and Eyles, C.H.
1985: The Application of Basin Analysis Techniques to Glaciated Terrains, an Example from the Lake Ontario Basin, Canada; Geoscience Canada, Volume 12, Number 1, p.22-32.

The Don Valley Brickyard, as a part of the Lake Ontario Basin, provided exposures of the Illinoian glaciation and the Sangamonian interglacial. As well, the Scarborough Bluffs revealed exposures of the last glaciation (Wisconsinan).

The basin analyses consisted of facies descriptions and analyses from available outcrop or core data along with basin-wide studies employing downhole geophysical well loggings, paleoecological, age and other data.

Extensive studies of the Scarborough Formation and overlying Sunnybrook diamict were undertaken. The Scarborough Bluffs were said to preserve the complex fill of a large lacustrine basin.

Eyles, N., and Clark, B.M.

1986: Significance of Hummocky and Swaley Cross-Stratification in Late Pleistocene Lacustrine Sediments of the Ontario Basin, Canada; Geology, Volume 14, p.679-682.

This paper provides a report on the presence of hummocky and swaley cross-stratification in glacial, last interglacial and postglacial sands deposited in the Ontario basin. This type of cross-stratification was previously found to be generated by storm wave events.

Hummocky cross-stratification was identified in the Don beds, the lower Thorncliffe sands and postglacial Lake Iroquois deposits. Hydraulic calculations provided estimates on water depth and wave climate under which these bedforms developed. The Don beds were deposited in water as shallow as 2 m with waves of 1.5 m in height and periods of 3 seconds.

The authors indicated that hummocky cross-stratification was probably a common facies of the nearshore zone in both the modern Great Lakes and Late Pleistocene lakes.

Fairchild, H.L.

1932a: New York Moraines; Geological Society of America Bulletin, Volume 43, Number 1, p.192.

The moraines of the Erie basin and on the Ontario plain, west of the Genesee Valley, were previously delineated by Leverett. This report extended the principal moraine belts and ice front positions eastward to the Mohawk Valley.

The moraines and accompanying drainage features proved the existence of an important deglaciation with the Ontario basin water level reaching sea level. This deglaciation was felt to be correlative with the Toronto interglacial deposits.

The interglacial stage was felt to have occurred in Late Wisconsinan time and was preceded and followed by a first and second glacial Lake Warren.

1932b: New York Glacial History and Toronto Interglacial Deposits; Geological Society of America Bulletin, Volume 43, Number 1, p.191-192.

A sequence of glacial drainage channels across central New York carried not only the impounded waters of the central New York valleys, but also the waters from glacial Lake Warren. The deglaciation interval in Late Wisconsinan time, with very low water in the Ontario basin, was of considerable extent in area, and in duration. This interval was believed to account for the interglacial deposits at Toronto.

The deglaciation stage was terminated by the readvance of the ice which formed a second Lake Warren. The lowering of the second Lake Warren involved the sequence of lower glacial lakes Dana, Dawson, and Iroquois.

Flint, R.F.

1947: Glacial Geology and the Pleistocene Epoch; Edited by R.F. Flint, John Wiley and Sons, New York, p.285-287,525.

This book provides an outline of Pleistocene glaciation in North America. Correlations of Pleistocene events based on geologic evidence, rather than climatic or archeologic evidence, are suggested.

The Sangamonian Interglacial was best known from the Toronto Formation, which was exposed in over twelve different areas around the Toronto region. The best sections were in the Don Valley Brickyard, the Leaside Brickyard and the Scarborough Bluffs. The Don beds are suggested to represent a major deglaciation at least as extensive as the one which now exists.

The exact age of the deposits was not precisely known, however it seems to the author that they were Sangamonian as they underlay Wisconsinan drift. Illinoian and Sangamonian erosion would likely have removed any deposits dating back to as early as Yarmouthian time. A.P. Coleman, at various times, suggested the beds to be of Aftonian, Sangamonian and Yarmouthian age.

1957: Stratigraphy of Central North America; *in* Glacial and Pleistocene Geology, Edited by R.F. Flint, p.340-341.

This book provides an overview of Pleistocene glacial processes and stratigraphy. A large section of the book was devoted to Pleistocene stratigraphy. The Sangamonian Interglacial was best known from the Toronto Formation which consisted of the Don and Scarborough beds. The flora and fauna of the Don beds indicated a temperature higher than present, which implied interglacial conditions. The Scarborough beds were thought to conformably overlie the Don beds and indicated a cooler climate, possibly recording an oncoming glacial episode. The age of the Toronto Formation was found, by radiocarbon dating, to be older than the classical Wisconsinan drift.

1971: Stratigraphy of Central North America; *in* Glacial and Quaternary Geology, Edited by R.F. Flint, p.553-554.

The third edition of this volume provides updated information on the Pleistocene history of central North America.

The Sangamonian aged Don Formation in the Don Valley Brickyards of Toronto was noted to be one of the more famous interglacial exposures. Illinoian aged York Till underlay these sediments.

Pollen records and fossil indicators from the bottom beds of the Don Formation indicated temperatures during their deposition were two to three degrees warmer than today. Beds further up section indicated a drop in temperature that led to the slow onset of a boreal forest type climate.

Freeman, E.B.
1976: Toronto's Geological Past—An Introduction; Ontario Division of Mines, Miscellaneous Publication, 1p.

Geological processes played an important part in the location and development of the city of Toronto. The harbour, Toronto Islands, local topography, and the lake bluffs all resulted from geological processes.

Glacial deposits were used to produce building materials such as bricks, while bedrock was utilized as building stone and as raw material for bricks.

Freeman described a number of sites having geological interest, including the Don Valley Brick yards, and provided notes on their formation and economic importance.

1978: Geology of the Greater Toronto Region; Toronto 1978, p.84-92 *in* Field Trips Guidebook, edited by A.L. Currie and W.O. Mackasey, Geological Society of America and Geological Association of Canada, 361p.

This field trip guide provides an overview of Toronto's geology from Precambrian to Quaternary. Only the Paleozoic and Quaternary deposits were noted to be seen in the area today.

The Pleistocene sequence was stated to be unusual in that two major glacial stages, Illinoian and Wisconsinan, were separated by a temperate climate Sangamonian Interglacial stage. These warm climate beds, the Don Formation, were thought to be some 130 000 to 200 000 years old. The underlying Illinoian York Till was dated at 275 000 years in age.

River cuts, the lake bluffs, and the Don Valley Brickyards exposed a series of early to Late Wisconsinan glacial and interstadial deposits.

Freeman, E.B., Sado, E.V., and Tovell, W.M.
1984: Physiography, Geology and Land Use, Toronto to Madoc; Field Trip Guide F1, NCGE-OAGEE Annual Meetings, Toronto, Canada.

This field trip guide outlines the geology at a number of sites in southern Ontario. In the Toronto region Quaternary stratigraphy was illustrated at the Don Valley Brickyard site and Scarborough Bluffs.

Freeman, E.B., and Tovell, W.M.
1985: Geology, Physiography, and Land Use: Toronto to Madoc; Edgeo Conference, National Association of Geology Teachers, Eastern Section Meeting, Ontario Association for Geographic and Environmental Education, Spring Conference Fieldtrip Guidebook, Toronto, Ontario.

This field trip guide outlines the Precambrian, Paleozoic, and Quaternary geology of southern Ontario. The Pleistocene geology at a number of locations is illustrated. Sites visited in the Toronto region included the Don Valley Brickyard and Scarborough Bluffs.

The Don Formation silts are noted to have yielded approximately 50 taxa of beetles, including several types of water beetles. *Daphnia ephippia* and numerous caddis fly remains indicate that the sediments were deposited in shallow water.

Gray, A.B.
1948: Ground-Water Resources of Scarborough Township, York County, Ontario; Geological Survey of Canada, Water Supply Paper (unpublished) Volume 290.

1950: Sedimentary Facies of the Don Member (Toronto Formation); Unpublished M.A. Thesis, University of Toronto.

The Don Member of the Toronto Formation was studied in detail with respect to lithology, sedimentology, and paleogeography. Exposures in the Don Valley Quarry and the former Sun Quarry provided the study sites.

The member is subdivided into three components: deltaic sediments; a group of lacustrine beds; and a water-laid deposit composed of thin bedded, medium to coarse sands and clay-like material. The third component is found to be totally lacking in calcium carbonate.

Griffiths, J.S.
1966: The Pleistocene Geology of the East and West Extensions of the Toronto Transit Commission's Bloor-Danforth Subway; Unpublished B.A.Sc. Thesis, University of Toronto.

Guillet, G.R.
1964: Clay and Shale in Ontario: A Review; Ontario Department of Mines, Preliminary Report 1964-2.

In 1962, Ontario's clay products industry had a value of approximately 20 million dollars. The clays and shales utilized in Ontario by the various operations were studied and sampled.

In the Toronto region, the oldest Pleistocene clays used in the manufacture of bricks were from the interglacial Don and Scarborough beds.

These beds, plus the Bloor Member varves, provided the raw materials at the Toronto Brick Company's Don Valley pit. The Don and Scarborough beds produced maroon-red brick while the Bloor varves produced buff-coloured brick.

1967: The Clay Products Industry of Ontario; Ontario Department of Mines, Industrial Minerals Report 22, 206p.

The author describes in detail the processes by which brick, tile, and other clay products were manufactured. A discussion of the producers using the Dundas shale, the Queenston shale, the Hamilton shale and clay deposits in Ontario is included.

A detailed geological outline of the Toronto Brick Company's Don Valley pit, including the Dundas shale, the clay beds, and accompanying strata is provided.

Guthrie, A.
1986: William Thomas Taylor and the Don Valley Pressed Brickworks; p.135-159 *in* Don Valley Legacy; A Pioneer History, Boston Mills Press, Erin, Ontario.

A chapter in this book outlines the history of the Don Valley Brickyards from its initial conception, up until the end of the Taylor brothers' ownership. The author states that the quarry became world famous as the entire glacial sequence of the Toronto area was exposed by excavations.

The Don Valley had long been a spot of interest to find fossilized fresh water shells or trees. The brick pits offered not only the widest range of interglacial fossils but also enabled scientists to discover the relationships between different beds and allowed them to work out the Pleistocene history of the region.

Dr. A.P. Coleman led several excursions and wrote numerous papers on the drift of the Don Valley Brickyards.

Hammond, P., Morgan, A., and Morgan, A.V.
1979: On the Gibbulus Group of the Genus *Anotylus* (C.G. Thomson), and Fossil Occurrences of *Anotylus gibbulus* (Eppelsheim) (Coleoptera, Staphylinidae); Systematic Entomology, Volume 4, p.215-221.

This paper outlines recent and fossil findings of the staphylinid *Anotylus gibbulus*.

A single fossil specimen of *Anotylus gibbulus* was discovered in the Don Formation at the Don Valley Brickyards. This specimen was the first of the species to be found in North America, extending the range of the fossil staphylinid thousands of miles beyond what was thought to be its present range in the region of the Caucasus Mountains. The contraction in the range of *Anotylus gibbulus* over the past 120 000 years appeared to be significant. The habitat of the present day gibbulus group was pointed out to be largely the dung of large herbivorous animals.

The contraction in range of this species was speculated to be related to climatic factors or to changes in range of large herbivorous animals.

Hann, B.J., and Karrow, P.F.
1984: Pleistocene Paleoecology of the Don and Scarborough Formations, Toronto, Canada, Based on Cladoceran Microfossils at the Don Valley Brick yard; Boreas, Volume 13, p.377-391.

The deposition of the Don and Scarborough Formations occurred while a disjunction in environmental conditions existed, as evidenced by cladoceran microfossils. The Don interval had warmer mean annual temperatures than did the Scarborough; however, climatic conditions were thought to be similar to present day conditions.

The deposition site was suggested to have been a shallow water, lentic habitat, as shown by the almost exclusive littoral species composition of the cladoceran community throughout the sequence.

From the proportions of the littoral to planktic species, the proportions of sediment- to vegetation-preferring chydorids and the species diversity and equitability, the past community structure, water depth, and trophic state changes at the site were able to be reconstructed.

Harrison, W., and Terasmae, J.
1961: Remanent Magnetism in Silts of Pleistocene Age from North America; Journal of Sedimentary Petrology, Volume 31, Number 3, p.448-452.

Sixty-four specimens of silts ranging in age from Kansan, through Illinoian, Sangamonian, and into Wisconsinan were tested for their remanent magnetization.

The Don Valley brickpits were sampled for Sangamonian-aged silts. The beds were identified as alluvial and lacustrine sands, silts, and gravels. Calcareous lacustrine silts were sampled from the Scarborough beds in the brickpits to study Wisconsinan aged silts.

Both the Sangamonian and Wisconsinan silts showed magnetic north pole positions within the expected secular variation of approximately north of the sixtieth parallel. However, it was noted that these magnetic fabrics might have instead have been imparted by ice flow stress on the deposits.

Henderson, E.P.
1951: A Statistical Analysis of the Coarse Fractions of Some Southern Ontario Tills; Unpublished M.Sc. Thesis, University of Toronto.

This thesis presents an analysis of clast lithology for a number of till sheets north of Lake Ontario. For the various till sheets studied, clast samples were taken and the lithology of the stones identified. Samples of Paleozoic and Precambrian bedrock from the same area were collected so as to allow lithological comparison between the tills and bedrock samples.

One of the samples studied was taken from the lowermost till exposed at the Don Valley brickworks. A significant percentage of the clasts (30.1%) were derived from the Upper Ordovician Utica Shale. The age of the lowermost till at the brickworks was stated to be Kansan or Nebraskan.

Hewitt, D.F.
1962: Urban Expansion and the Mineral Industry in the Toronto-Hamilton Area; Ontario Department of Mines, Industrial Mineral Report 8, 11p.

This report outlines the major sites of mineral resources and production within the the Toronto-Hamilton area. Reports on sand and gravel, crushed stone, dolomite and limestone, brick and tile, sewer pipe, building stone, Portland cement, gypsum and lime, are included.

The Toronto Brick Company's Don Valley plant is referred to under brick and tile producers of York County.

Hewitt, D.F., and Karrow, P.F.
1963: Sand and Gravel in Southern Ontario; Ontario Department of Mines, Industrial Mineral Report 11, 151p.

A detailed discussion of producers, specifications, processes, and tests for sand and gravel deposits in Ontario can be found in this report.

Included are: a description of types of sand and gravel deposits, including stream and river, beach, and glacial deposits; an explanation of glacial deposits including the Illinoian stage glaciation, the Sangamonian interglacial, and the Wisconsinan glacial stage; and a county by county breakdown of pits and pit location maps.

Hinde, G.J.
1877: The Glacial and Interglacial Strata of Scarboro' Heights, and Other Localities Near Toronto, Ontario; Canadian Journal (new series)(defunct), Volume 15, Number 94, p.388-413.

In this paper, Hinde describes his observations on glacial and interglacial deposits exposed along the Scarborough bluffs.

Scarborough Heights were noted to extend for some 9 1/2 miles, rising from lake level up to an elevation of 170 to 190 feet. Underlying the cliff are the Hudson River (Georgian Bay Formation) Group's bluish flagstones and shales. The following succession was found to overlie the Paleozoic rocks: 1) till or boulder clay; 2) interglacial fossiliferous clay; 3) interglacial fossiliferous sand; 4) till or boulder clay; 5) interglacial laminated clay and sand; 6) till or boulder clay; and 7) postglacial stratified sand and gravel.

Large Laurentian erratics found on the plateaus of the bluffs resulted from the melting of ground glaciers, according to Hinde. The author indicates three separate glaciations, with intervening milder periods preserved in the section.

Hui, H.T., Fernando, C.H., and Karrow, P.F.
1969: Mollusca of the Toronto Interglacial; American Zoologist, Volume 9, p.615-616.

This study focuses on the biostratigraphic and paleoecologic aspects of mollusc assemblages from the Don Formation. Approximately 60 species of molluscs, almost all of which are freshwater forms, were identified. The malacological interpretation of the nature and changes of the depositional environments are compared with those of other sources.

Kalas, L.L.
1975: Malacological Evidence of Interglacial Environments at Toronto, Ontario, Canada: A Quantitative Approach; Quaternary Non-Marine Paleoecology Conference, Program with Abstracts, Waterloo, Ontario.

An exposure of the Don Formation in the western portion of the Don Valley Brickyard was sampled for shelled invertebrates. A total of more than 55 species of molluscs were recovered. The most diverse group were Sphaeriacean clams, Prosobranchia, and Unionaceans. Paleoenvironmental reconstruction indicated that the sediments were deposited by a medium sized river, larger than the present Don River, which drained into a nearby lake embayment. Episodic shallowing of water was noted near the base and upper parts of the Don Formation.

Kapp, R.O.
1977: Late Pleistocene and Post Glacial Plant Communities of the Great Lakes Region; p.1-26 *in* Geobotany, edited by R.C. Romans, Plenum Publishing, New York.

This article deals with the pollen record and outlines plant communities which were present within the Great Lakes region during the Late Pleistocene.

The interglacial phases III and IV occurred prior to the approach of the Wisconsinan ice sheet and were documented in the Don beds at Toronto. Pollen records from these beds indicated a mean annual temperature of 3 to 5° Fahrenheit warmer than the present.

A detailed documentation of appearance and disappearance of tree species for the studied region is also provided.

Karrow, P.F.
1959: Palynological Study of the Interglacial Beds, Scarborough Bluffs, Toronto, Canada; Ontario Department of Mines (Unpublished Report).

The evidence supplied through numerous plant and animal fossils, as well as pollen and spore remains, indicated that the Don beds were deposited in a fresh water environment, probably 5° Fahrenheit warmer than the present.

The Scarborough beds were deposited under boreal climatic conditions with mean annual temperatures probably 6 to 10° lower than present.

A correlation between the Scarborough beds and the St. Pierre nonglacial sequence in the St. Lawrence Lowland was suggested by palynological studies.

1964: Pleistocene Geology, Toronto-Scarborough Area; p.81-91 *in* Guidebook, Geology of Central Ontario, by the American Association of Petroleum Geologists.

According to the author, the Pleistocene geology at Toronto was best exposed in the Don Valley Brickyard and at the Scarborough Bluffs. This paper provides a summarized history of the Pleistocene sequence at Toronto and examines the regional stratigraphic framework.

1967: Pleistocene Geology of the Scarborough Area; Ontario Department of Mines, Geological Report 46, 108p.

This report outlines the Pleistocene geology of the Scarborough area.

Pleistocene deposits some 100 to 400 feet thick cover the bedrock surface. These include both glacial and interglacial deposits. The oldest identified deposit is the probable Illinoian-aged York

till. The fossiliferous interglacial Don Formation is classified as Sangamonian age, as warm climate wood and shells are present. The Scarborough Formation, of Early Wisconsinan age, contained plants indicative of a cool climate. The overlying Sunnybrook Till is stated to be Early Wisconsinan in age. The interstadial Thorncliffe Formation was found to be interbedded with two apparently minor till sheets, named the Seminary and Meadowcliffe Tills. The uppermost Leaside Till is Late Wisconsinan in age. Postglacial Lake Iroquois cuts a prominent shorecliff across the area approximately 200 feet above the present Lake Ontario level. Erosion by Lake Ontario creates spectacular exposures in the lake bluffs.

1969: Stratigraphic Studies in the Toronto Pleistocene; Geological Association of Canada, Proceedings, Volume 20, p.4-16.

The Pleistocene stratigraphy of the Toronto region was established during the late 1800s by Hinde (1877) and later updated by Coleman (1932). They describe three main glacial and three nonglacial intervals which include postglacial deposits.

The oldest deposit, the York Till of Illinoian age, is overlain by a warmer climate fluvial, shallow lacustrine (Sangamonian?-aged) deposit, the Don Formation. In the overlying Scarborough Formation, fossils indicative of a cool climate were found. The age of this deposit was thought to be Early Wisconsinan. The Scarborough beds were deposited in a lake 150 feet higher than present, which resulted from an ice dam in the St. Lawrence valley. Drainage of this lake cut channels into the Scarborough beds which were subsequently infilled. Early Wisconsinan ice advanced across the area and deposited the Sunnybrook Till.

The Middle Wisconsinan deposits are predominantly nonglacial with sands and clays of the Thorncliffe Formation being deposited. The Late Wisconsinan was marked by the presence of the Leaside Till. The glacial sequence ended with the postglacial lake sediments of Lake Iroquois, which were deposited about 12 000 years B.P.

1974: Till Stratigraphy in Parts of Southwestern Ontario: Geological Society of America Bulletin, Volume 85, p.761-768.

This paper presents an update of the glacial stratigraphy for southwestern Ontario. New names for previous informally named deposits are provided.

In the Toronto region, an interval of lowered base level, which occurred during the St. Pierre interstadial, is represented by several deep cuts into the Early Wisconsinan Scarborough Formation. These valleys were subsequently filled with stream sediments. The proposed name for these deposits is the Pottery Road Formation and the type section is located at the Don Valley brickworks.

1976: The Interglacial-Glacial Transition in the Toronto Interglacial; Geological Society of America, 1976 Annual Meeting, Abstracts with Programs, p.946-947.

Four formations exposed at the Don Valley Brickyard record changing climates and paleogeography from the interglacial (Sangamonian?) Don Formation to the first subsequent glaciation.

The Don Formation records a cooling climate sequence with warm climate fossils located near the base, and cooler climate species at the top. The overlying Scarborough Formation records a high water level in the basin, due to ice damming of the St. Lawrence River. The sediments contain cool climate fossils. Reopening of the St. Lawrence outlet is suggested by the presence of valleys, up to 45 m deep, which were cut into the Scarborough and Don beds. The valleys were filled, in some areas, by channel fill deposits of the Pottery Road Formation. Fossil records indicate some climatic warming took place at this time, however, this was inconclusive. Initial glaciation was represented by the Sunnybrook Till. The time span for the change from full interglacial to full glacial is suggested to have been in excess of 10 000 years.

1984: Quaternary Stratigraphy and History, Great Lakes-St. Lawrence Region; p.137-153 *in* Quaternary Stratigraphy of Canada—A Canadian Contribution to IGCP Project 24, edited by R.J. Fulton, Geological Survey of Canada, Volume 84-10.

The Illinoian York Till of Toronto is overlain by the Don Formation and its warm climate fossils. The Scarborough Delta with cool climate fossils is related to the oldest Early Wisconsinan ice advances. An ice retreat deposited the Pottery Road Formation and the subsequent advance left the Sunnybrook Till at Toronto. The Thorncliffe Formation consists of interstadial deposits of early Middle Wisconsinan. Ice advances then covered the area.

Many tills were deposited by Late Wisconsinan ice advances in the Great Lakes area. Ice retreat produced a series of complex glacial lakes. The Champlain Sea temporarily flooded the downwarped St. Lawrence Valley but isostatic upwarp reinstated terrestrial conditions.

1986: Hogtown's Geological Base; Canadian Institute of Mining, Volume 107, Number 1, p.47.

The Taylor Brickyard operated from the late 19th century until the mid-1980s. Originally the brickyard used the overburden clay to produce its bricks but later utilized the Georgian Bay Formation shale.

Many fossils (wood, shells, bones, and teeth) found within the overburden (Don Beds), and glacial beds present both above and below, suggest that the Don Beds were deposited during an interglacial. Recent studies concentrated more on microscopic fossils such as pollen, diatoms, insects, and others. These studies indicate that the Don Beds are around 125 000 years old.

A move to buy the old brickyard site, with the intention of preserving the historically and geologically important site as a park, was undertaken by the Ontario Government.

Karrow, P.F., Clarke, A.H., and Herrington, H.B.
1972: Pleistocene Molluscs from Lake Iroquois Deposits in Ontario; Canadian Journal of Earth Sciences, Volume 9, p.587-595.

Previous work by A.P. Coleman indicated that mollusc fossils were found in Toronto as part of Lake Iroquois deposits at a locality known as Reservoir Park. It was discovered that the genera from this site were found in no other Lake Iroquois deposits. They were, however, found in the brickyards of the Don Valley as well as in other Toronto sites. These genera are stated to be of Early Wisconsinan age and to be interglacial rather than deposits of Lake Iroquois.

Karrow, P.F., Cowan, W.R., Dreimanis, A., and Singer, S.N.
1978: Middle Wisconsinan Stratigraphy in Southern Ontario; p.17-27 *in* Toronto 1978, Fieldtrips Guidebook, edited by A.L. Currie and W.O. Mackasey, Geological Society of America and Geological Association of Canada.

This field trip guidebook outlines important Middle Wisconsinan sections of Southern Ontario. The Middle Wisconsinan substage was previously defined for the Great Lakes-St. Lawrence region by Dreimanis and Karrow (1972) as "a relatively warmer time of glacial retreats extending from about 53,000 years ago to 23,000 years ago". The beginning of the Middle Wisconsinan was shifted to an older date of some 70 000 years.

Of particular interest in the Toronto area are, from oldest to youngest, Middle Wisconsinan deposits of the Lower Thorncliffe Formation sands, Seminary Till, Middle Thorncliffe Formation, Meadowcliffe Till, and Upper Thorncliffe Formation. Exposures of these deposits were seen at the Scarborough Bluffs and in the Don Valley Brickyards.

Karrow, P.F., Jopling, A.V., and Martini, I.P.
1982: Late Quaternary Sedimentary Environments of a Glaciated Area: Southern Ontario; 11th International Association of Sedimentologists Congress, Field Trip Guide, Hamilton, Ontario. Volume 11A.

This fieldtrip guidebook examines a variety of glacial, glaciofluvial, and glaciolacustrine deposits as well as interstadial, interglacial, and postglacial deposits in southern Ontario.

A field stop at the Don Valley Brickyard examined the shale-rich York Till, the Sangamonian aged Don Formation, the laminated clays of the Pottery Road Formation, the Early Wisconsinan Sunnybrook drift, and a thin veneer of Lake Iroquois nearshore sand.

The Don Formation is noted to be famous for it's warm climate fossils. The most notable large vertebrate fossil so far found was the extinct giant beaver, *Castoroides chioensis*.

Karrow, P.F., and Kerr-Lawson, L.J.
1986: Fossils From the Interglacial Don Formation, Toronto, Canada; American Quaternary Association, Program with Abstracts of the 9th Biannual Meeting, p.90.

The Don Formation, as exposed in the Don Valley Brickyards, was noted to be underlain by the York Drift and overlain by the Scarborough Formation, the Pottery Road Formation, the Sunnybrook Drift, the Thorncliffe Formation, and the Halton Till. Previous studies found large numbers of diatom, mollusc, ostracod, insect, Cladocera, and vertebrate taxa. This study observed an additional 33 mollusc and 55 plant taxa. The report indicates that water was always present during deposition of the Don Formation. In addition, it is postulated that temperatures cooled toward the top of the deposit.

Karrow, P.F., and Morgan, A.V.
1975: Quaternary Stratigraphy of the Toronto Area; Geological Association of Canada, Mineralogical Association of Canada, Geological Society of America, Field Trip, Volume 6, p.161-179.

The Woodbridge Railway cut was found to have deposits ranging in age from Illinoian to Late Wisconsinan. Extensive slumping covered much of this cut, with a small stream maintaining limited exposure.

The Don Brickyard has provided the chief interglacial Don Formation exposure since the nineteenth century. The Don Formation beds indicate a warmer climate, whereas both the Scarborough and Pottery Road Formations suggest a cooler climate.

The Scarborough Bluffs provide major Early Wisconsinan Scarborough Formation exposures. A series of four tills with interbedded sand and silt are found there. The Brimley Road access and the Cudia Park section were also visited.

Keele, J.Z.
1924: Preliminary Report on the Clay and Shale Deposits of Ontario; Geological Survey of Canada Memoir, Volume 142, Number 123.

The clay and shales of Ontario provide the raw materials for the provinces clay products industries. The shales utilized by the industry come mainly from the Queenston and Lorraine (Georgian Bay) Formations. Much of the clay used in Ontario comes from material of glacial origin.

The Toronto area supplied an abundance and variety of raw materials unequalled in any other part of the province. Glacial materials used were from three horizons, classified by Coleman (1909) as Iroquois clay, Upper Interglacial clay, and Lower Interglacial clay (Toronto Formation). The Upper and Lower Interglacial clays were used extensively at the Don Valley Brick Company pit. The Lower Interglacial clay produced a

dark reddish brown brick. Many of the finer houses in Toronto are faced with bricks made from the Toronto beds.

Keele also provides a revised stratigraphic classification from Coleman's earlier 1909 version. He considered the oldest till to be Illinoian (York Till), the Don and Scarborough beds to be interglacial, and the overlying tills to be of Wisconsinan age.

Kelly, R.I., and Martini, I.P.

1986: Pleistocene Glaciolacustrine Deltaic Deposits of the Scarborough Formation, Ontario, Canada; Sedimentary Geology, Volume 47, p.27-52.

The Scarborough Formation was examined to provide information on lithofacies and depositional environments. It is best exposed along the Lake Ontario bluffs but is also seen along many of the river and stream valleys running through Toronto.

This formation represents a lacustrine-deltaic sequence in which sedimentation patterns may have been affected by nearby glacial ice. Peculiar features of this deposit include varve-like, clay-rich rhythmites in the basal part of the deposit, "massive" laterally extensive silty beds in the lower and middle parts, and a thick accumulation of sand in the upper part of the sequence. At the Don Valley section, only the lower part of the sequence is present.

Kerr-Lawson, L.J.

1985: Gastropods and plant macrofossils from the Quaternary Don Formation (Sangamonian Interglacial), Toronto, Ontario; Unpublished M.Sc. Thesis, University of Waterloo.

A continuous section of Sangamonian Interglacial Don Formation was sampled for gastropods and plant macrofossils. Most gastropods were found to be fresh water species with 11 previously unidentified species added to the published fossil mollusc list. Seven species of land snails were also added.

All of the gastropods are known to be presently found in the Great Lakes region, *Valvata perdepressa* being the most common species. Stable isotope analysis of shells indicate that they lived in a large temperate lake with abundant vegetation.

In addition, 55 plant species were added, with the lower beds dominated by aquatic species and plants having more southern affinities. The upper beds had more upland tree species with indications of a boreal succession. The presence of aquatic seeds, *Najas sp.*, indicated that water was present throughout deposition of the Don beds. Further studies on pelecypods, bone, fish scales, and insects are suggested.

Lajtai, E.Z.

1961: Pleistocene Geology of the University Avenue Subway Route, Toronto; Unpublished M.A. Thesis, University of Toronto.

1966: Pleistocene Sediments of the Bloor-Danforth Subway Section, Toronto, Canada; Unpublished Ph.D. Thesis, University of Toronto.

This study investigates the Pleistocene geology that was exposed in excavations and boreholes made for the Bloor-Danforth subway line in Toronto.

The sediments were found to be for the most part tills and varved clays. Seven tills, that were previously defined as separate units within the Wisconsinan, were combined to form four possible separate units. Three major groups of varved clays were distinquished. All of these groups conform to a turbidity current hypothesis.

It is suggested that the Don and the Scarborough Formations were separated by a glacial readvance, the deposits of which were referred to as the Bartlett sediments. Two hypotheses were formed regarding these sediments; either they are Illinoian glacial deposits, or they are Early Wisconsinan sediments.

The Queen's Park silts, and the Sherbourne, Coxwell, and Greenwood Tills were deposited during the Sunnybrook episode and are called the Sunnybrook drift.

1969: Stratigraphy of the University Subway, Toronto, Canada; Geological Association of Canada Proceedings, Volume 20, p.17-23.

Excavations for the University-Bloor-Danforth subway lines revealed Pleistocene sediments which were compared with the stratigraphy observed at the Don Valley Brickyards and Scarborough Bluffs.

The oldest glacial deposits, a clayey till and overlying varves, are assigned to the Illinoian. Lying above these are the Sangamonian interglacial sands of the Don Formation and the cool-climate Scarborough beds. This sequence is overlain by the Early Wisconsinan Sunnybrook Drift. The lower part of this drift consists of glaciofluvial sands (now called the Pottery Road Formation), a middle till unit, and overlying varved sediments (Bloor member varves). Overlying the Sunnybrook Drift varved clays is a till-stratified sand complex informally termed the St. George Till. This till, on the basis of carbonate parameters is compared with the Seminary, Meadowcliffe, and Leaside Tills. It is suggested that the St. George Till is correlative with the Leaside Till.

Lemon, J.H.

1898: Interglacial Shells at Toronto, Canada; Nautilus, Volume 12, Number 1, p.6-7.

A conchological study of the present Don River indicated that some species are missing from the assemblage for the Don Beds. Three of the Unios species (*U. pustulosus*, *U. solidus*, and *U. clavus*),

found in the Don Beds were found to be confined to the lower Mississippi River system. The presence of the Mississippi forms seem to indicate a more southern climate. This conclusion is supported by the plant remains.

Leverett, F.
1903: Summary of the Literature of North American Pleistocene Geology, 1901 and 1902, II; Journal of Geology, Volume 11, p.500-501.

Leverett summarizes the findings from a number of Pleistocene geology papers published in the years 1901 and 1902. One of the papers reviewed is A.P. Coleman's "Glacial and Interglacial Beds Near Toronto". Leverett questions Coleman's assignment of the lowermost till to the Iowan glacial interval. The author suggests that the Toronto interglacial belonged to the longer nonglacial period between the Illinoian and Iowan glacial intervals. Thus, the lowest till layer at Toronto would belong to the Illinoian instead of the Iowan interval.

Maclean, D.R.J.
1949: Scarborough Bluffs; Unpublished B.A.Sc. Thesis, University of Toronto.

Maury, C.J.
1908: An Interglacial Fauna Found in Cayuga Valley and Its Relation to the Pleistocene of Toronto; Journal of Geology, Volume 16, p.565-567.

An interglacial fossiliferous deposit was discovered on the western shore of Cayuga Lake in New York. The section contained fossiliferous blue clay which lay 10 to 15 feet above Devonian shales. Between the shales and clay was an oxidized boulder clay. Fossils recovered from the clay were found to be all fresh water forms with Unios, Anodontas, and Spaeriums most common. More than half of the identified species were also found in the Toronto interglacial beds approximately 170 miles northwest. In addition to species similarity, elevations of the deposits were also comparable. It is suggested that the Cayuga deposit corresponded approximately in time with the warm climate Don Beds, which are regarded as representing the Peorian, or fourth interglacial period.

Mirza, C., Engineering Inc.
1984: A Feasibility Study for the Protection and Management of Significant Geological Features: Don Valley Brickyard; The Ontario Heritage Foundation.

This study outlines the engineering needs required to stabilize and minimize the erosional degradation which was occurring in the Don Valley Brickyards. It also provides an evaluation of the geotechnical engineering parameters significant to the future preservation and conservation of the Brickyard exposures. Geotechnical properties of several stratigraphic units including the York Till, the Don Beds, the Scarborough clay, the Pottery Road Formation and the Sunnybrook Drift are discussed.

Montgomery, R.J.
1930: The Ceramic Industry of Ontario; Ontario Department of Mines, Annual Report for 1930, Volume 39, Part 4.

This report examines in detail the ceramics industry of Ontario with regards to both the shale and clay deposits that were used for raw material.

The interglacial Don and Scarborough beds of the Toronto Formation provided clay raw material at the Don Valley Brickyards in Toronto. The upper interglacial clay was noted to consist of an upper yellowish silty clay, a grey, stratified, plastic clay, and a clay containing massive stony bands with scattered pebbles.

The lower interglacial clay (oldest brick clay in Ontario) was overlain by a layer of glacial drift and the upper interglacial clay at the brickyards.

A map of the heavy clay products in Ontario is included.

Morgan, A.
1971: The Fossil Occurrence of *Helophorous arcticus* Brown (Coleoptera: Hydrophilidae) in Pleistocene Deposits of the Scarborough Bluffs, Ontario; Canadian Journal of Zoology, Volume 50, p.555-558.

This paper documents the first reported fossil occurrence of *Heliophorus arcticus*. *Heliophorus arcticus* was known to be presently found living in damp tundra regions, under a subarctic climate, at or near the timber line around 60° north parallel. The finding of this fossil beetle indicated that a subarctic climate existed in the Toronto region 70 000 years ago when the Scarborough Formation, from which the fossils were extracted, was deposited. This also suggests a vast change in insect distribution has taken place since the last glaciation.

1975: Fossil Beetle Assemblages from the Early Wisconsin Scarborough Formation, Toronto, Canada; Quaternary Non-marine Paleoecolgy Conference, Program with Abstracts, University of Waterloo, Ontario.

Samples were collected in a vertical sequence through the Scarborough Formation and analyzed for fossil invertebrates. Beetles were found to be most common with 100 taxa noted, 30 of which were specifically identified. Contrary to Scudder's (1877, 1890a, 1895) findings, no extinct species were recognized with certainty.

The faunal assemblages showed no major climatic variations during deposition of the Scarborough sediments. The majority of species lived near the northern limits of the boreal forest. This suggested that the tree line was probably close to Toronto at that time.

Morgan, A., and Morgan, A.V.
1976: Climatic Interpretations from the Fossil Insect Faunas of the Don and Scarborough Formations, Toronto, Ontario, Canada; Geological Society of America, Abstracts with Programs, Volume 8, p.1020.

Insect fossils collected from the Don Valley Brickyards and Scarborough Bluffs in Toronto indicate that the Sangamonian Don beds were deposited under a deciduous environment. The annual temperature averaged 4.5 to 7.5° Celsius. The Scarborough beds overlying the Don beds were deposited at a boreal forest-tundra boundary with the average annual temperature being -9.5 to -6.5° Celsius.

One hundred years ago the fossil beetles found in these sections were thought to be extinct; they are, however, known to be living in widely differing geographical locations today.

Morgan, A.V.
1977: Fossil Coleopteran Assemblages as Sensitive Indicators of Climatic Change During the Devensian (last) Cold Stage: Discussion; Royal Society of London Philosophical Transactions, Volume B, Number 280, p.339-340.

Beetle species were found to show a remarkable shift in distribution from known fossil localities to present ranges. The author points out that many of the species found in the Early Wisconsinan Scarborough Formation are presently found along the northern treeline in Canada. Some fossils, *Diacheila polita* and *Helophorus sibiricus*, shifted over 4000 km from their fossil locality. A lack of extensive collections in Canada prevent more accurate estimates of distribution shifts for many beetles from being made.

1981: A Field Guide to the Don Valley Brickpit and the Scarborough Bluffs, Toronto, Ontario; p.449-460 *in* Quaternary Paleoclimate, edited by W.C. Mahaney, Geoabstracts, Norwich.

The Pleistocene sequence at Toronto is spectacularily exposed at the Scarborough Bluffs and Don Valley Brickyard. This field guide provides a historical summary of Pleistocene studies at Toronto and outlines the present stratigraphic and depositional interpretations. Field stops included the Don Valley Brickyard and Scarborough Bluffs.

Morgan, A.V., and Morgan, A.
1979: Paleoentomological Methods of Reconstructing Paleoclimate with References to Interglacial and Interstadial Insect Faunas of Southern Ontario; Canadian Entomologist.

Much of the early work regarding fossil insects led to confusion between extinct and extant forms because misidentification of genera and species occurred. Recent work attempted to correlate shifts in insect distribution with climatic changes.

In North America, much of the work concerning climatic changes had only been carried out since the early 1970s. One of the most studied sites was the Don Valley Brickyard in Toronto. Here a wide variation in climatic regime was found to be preserved between the Sangamonian, Early Wisconsinan and Middle Wisconsinan deposits. The Don Formation, which is Sangamonian in age, contains a faunal assemblage which indicates a climate very close to conditions around Toronto today. The Early Wisconsinan Scarborough Formation, on the other hand, was found to represent a subarctic climate not unlike that of the southern part of the Northwest Territories today.

1980: Faunal Assemblages and Distributional Shifts of Coleoptera During the Late Pleistocene in Canada and the Northern United States; Canadian Entomologist, Volume 112, p.1105-1128.

A faunal list of 362 subfossil Coleoptera from 57 published and unpublished sites of Pleistocene age in the United States and Canada is provided. The distribution of families through intervals of Pleistocene time is examined and illustrates the distributional changes which occurred through the last interglacial-glacial-present interglacial cycle.

Many species whose modern range was found to be confined to northwestern North America were identified in Pleistocene deposits of the Great Lakes region. A distributional shift of some 4000 km was indicated for some species. The greatest distance so far recorded was represented by *Anotylus gibbulus*, which is known to presently inhabit the Caucasus mountains of Russia. This represents a shift of over 9000 km. The specimen was discovered in the Don Formation at the Don Valley Brickyards.

1980: Beetle Bits: The Science of Paleoentomology; Geoscience Canada, Volume 7, Number 1, p.22-28.

This paper briefly summarizes some of the work done by the Morgans in using Coleoptera (beetles) as climatic and vegetational indicators in Quaternary sequences. Several Quaternary sequences in North America were analyzed for fossil insects and many of them contained beetle remains. Beetles appeared to respond rapidly to climatic changes whereas other indicators were found to be less sensitive in detecting similar changes.

One of the most intensely studied sections was the Don Formation, which is Sangamonian in age, exposed at the Don Valley Brickyards. Studies of beetles and other insects indicate a climate very similar to present day Toronto. It also suggests that the Toronto area was vegetated by a mixed deciduous and coniferous woodland which bordered a slow moving river with well vegetated banks. This southward flowing river entered a lake with a water level much higher than present day Lake Ontario. The average July temperature was approximately 20° Celsius.

The climatic regimes of the Don and Scarborough Formations were very different, although it was

not known over what time period this deterioration of climate occurred.

1982: Changing Environments During the Sangamon, Wisconsin and Holocene in North America—The Evidence From Fossil Coleoptera Assemblages; XI Inqua Congress, Moscow, Abstracts, Volume 2, p.198.

Many sites in Canada and the United States were examined for fossil insect remains. An assumed Sangamonian-aged site from Baffin Island produced treeline species that indicate a warmer climate than present at that location. At Toronto, the Don Formation, which is Sangamonian in age, yielded insect assemblages suggestive of climatic conditions similar to present day.

The Early Wisconsinan Scarborough Formation contains boreal species (lower Scarborough), treeline assemblages (upper Scarborough and Woodbridge site), and possible tundra species (Beaver Valley). The insect assemblages suggest climatic deterioration in front of an advancing ice sheet.

Other fossil sites from various Wisconsinan periods are also described and climatic interpretations provided.

Oke, W.C.

1964: The Pleistocene Section on the Don and Little Don Rivers, Ontario; Unpublished M.Sc. Thesis, University of Toronto.

Using specific criteria, an attempt is made to differentiate, group, and correlate Pleistocene deposits. The criteria employed are: mechanical textural analysis (percentage of size fraction grades, size of median diameter, sorting, and skewness); carbonate analysis (percentage of calcite, percentage of dolomite, percentage of total carbonates, and ratio of calcite to dolomite); pebble lithologies; and heavy and light minerals (percentage of heavy and light minerals and ratio of purple to red garnets).

Pleistocene till, gravel and sand, and silt, clay, and varved clay were analyzed; however, no one criteria was found which could significantly differentiate, group, and correlate them all. Differentiation among gravels and sands as well as correlation among tills appeared acceptable. Differentiation of tills and silts and clays, the correlation of gravels and sands, and silts and clays, and the grouping of tills, gravels, and sands were, however, unreliable.

Olson, E.A., and Broecker, W.S.

1959: Lamont Natural Radiocarbon Measurements V; American Journal of Science, Radiocarbon Supplement, Volume 1, p.1-28.

This volume presents a summary of radiocarbon dates obtained by various laboratories. A sample of wood from the lower part of the Don beds was submitted to the Lamont laboratories for dating. The sample produced an age of greater than 46 000 years. The Don beds were thought by Watt (1953) to be of Sangamonian age.

Ontario Ministry of the Environment

1982: Water Well Records for Ontario: Regional Municipality of York 1946-1979; Ontario Ministry of the Environment, Water Resources Bulletin, 492p.

This publication provides a compilation of all water-wells sunk in the municipality of York between the years 1946 and 1979. Records detail the sediments encountered during the sinking of individual wells.

Ostry, R.C.

1962: An Analysis of Some Tills in Scarborough Township and Vicinity; Unpublished M.A. Thesis, University of Toronto.

In order to differentiate tills without using stratigraphy, several methods were applied to tills from Scarborough Township. Field evidence was confirmed by mechanical analysis, and a wide scale differentiation between Illinoian, Early, and Late Wisconsinan tills was possible using pebble lithologies. Carbonate gasometric analysis gave more precise results, while heavy mineral analysis, using garnets, provided some differentiation. Pleistocene ice movement information was partially supplied through micro- and macrofabric studies.

The movement of ice, which was lobate, and fanned out onto higher surrounding ground, was influenced by the Lake Ontario basin.

Penhallow, D.P.

1894: Note on Interglacial Plants from the Don Valley; The American Geologist, Volume 13, p.93-95.

A number of plants from the interglacial beds of the Don Valley provided much insight into the vegetation which existed at the time of deposition.

Three samples of interglacial lignite produced fragments of branches several inches in diameter. The identified specimens included the following species. Specimen 1 was identified as belonging to the genus of Fraximus, and of existing species most closely resembled *F. quadrangulata*. This appeared to be the first record of this genus from the interglacial of Canada. This genus is stated to be presently found along the shores of Lake Erie.

The second species identified was *Taxus baccata L., var. canadensis* Gray. This species was found to be quite common in the interglacial beds of Canada.

Specimen 3 most closely resembled *Quercus obtusiloba* Michx (oak). This represented the first record of oak found in the interglacial of Canada.

1896: Contributions to the Pleistocene Flora of Canada; Royal Society of Canada Transactions (Second Series), Volume 2, Volume 4, p.59-77.

This report gives an account and description of recent Pleistocene fossil flora finds in Canada. Also included is a complete listing of 63 separate genera and species found in Canada.

Of these, there are nine distinct species of Pleistocene plants occurring in the Don Valley, six of which are southern climate types, while the other three are moderate type climates. These plant remains indicate that a warmer climate was present at the time of deposition of the Don beds in the Don Valley.

The Pleistocene flora obtained from the Scarborough Heights indicate a climate similar to the present, but probably harsher.

1904: Notes on Tertiary Plants from Canada and the United States; Royal Society of Canada Transactions (Second Series), Volume 10, Volume 4, p.57-76.

Detailed studies of the floral succession, in conjuction with ice movements, were undertaken using the Pleistocene deposits in the Don Valley at Toronto. Three well defined phases of plant migration were shown to occur during glacial times. Initially, plants now characteristic of more southerly climates (middle United States) inhabited the region. As the ice advanced, the regional flora changed to a boreal type environment. When the ice again retreated, northward migration of vegetation occurred to give the present day floral assemblages. This assemblage represents a cooler climate than the initial stage, but a warmer climate than the boreal stage.

Detailed lists and descriptions of Tertiary plants that had been found in the Don Valley Brick yards, approximately 14 in all, are supplied by the author. All but two of the plants existed in the warm climate Don beds. One of the remaining was from the cold climate Scarborough beds and the other was found in the more recent mild climate Green Creeks clay.

These plant remains, when compared to modern day ancestors, give good indications of the range of the migration of the floral assemblages.

Perrault, Guy

1951: Stratigraphy and Sedimentation of the Western Section of the Scarborough Bluffs; Unpublished M.A.Sc. Thesis, University of Toronto.

The western section of the Scarborough Bluffs was analysed through vertical sections at 500-foot intervals. Vertical thickness and vertical angles were measured and extensive sedimentation analysis was carried out.

Poplawski, S., and Karrow, P.F.

1981: Ostracods and Paleoenvironments of the Late Quaternary Don and Scarborough Formations, Toronto, Ontario; Canadian Journal of Earth Sciences, Volume 18, Number 9, p.1497-1505.

Twelve species of ostracods were identified in type section exposures at the Don Valley Brick yard and at the Scarborough Bluffs. *Candona rawsoni* and *Candona caudata* were found to be the most abundant in the Don Formation and *Candora caudata* was the most abundant of the four species found in the cooler climate Scarborough Formation.

The Don Formation species indicated a fluvial and lacustrine environment at the brickyards, and a more dominantly lacustrine environment (fewer species) at the bluffs. The Scarborough Formation suggests a much cooler lacustrine environment.

Prest, V.K.

1970: Quaternary Geology of Canada; p.675-764 *in* Geology and Economic Minerals of Canada, Geological Survey of Canada, Economic Geology Report, edited by R.J.W. Douglas, Volume 1, Number 5.

This book contains a chapter which outlines the general Quaternary history of Canada. The nonglacial Pleistocene deposits of the Toronto region were especially noteworthy. The deposits exposed in the Don Valley had been documented since the late 1800s. The Don, Scarborough, and Pottery Road Formations were especially significant. The Don beds contain fossils indicative of a climate some 5° Fahrenheit warmer, on average, than at present. Sediments were deposited in a lake which stood some 60 feet higher than present, but the lake level began to fall during deposition of the middle and upper parts of the formation. This was indicated by the diatom assemblage in the middle section and the sandy nature of the upper strata.

The Scarborough Formation is stated to represent a delta which formed in a lake which stood approximately 200 feet higher than at present. The fossils present in the sediments indicate a cool climate. The Scarborough beds were estimated to be older than the St. Pierre organic-rich sediments of Quebec.

The St. Pierre beds were correlated with the Pottery Road channel fill sediments which overlie the Scarborough Formation. The Pottery Road Formation provided the first noted occurrence in Canada of the gastropod *Hendersonia occulta*.

Pullen, M.J.

1966: The Pleistocene Geology of Toronto as Seen from the Bloor-Danforth Subway Cut; Unpublished M.A.Sc. Thesis, University of Toronto.

This report deals with the stratigraphic section exposed along a 6 1/2 mile long and 50 foot deep subway excavation. Underlying the bottom of the exposure were the sandy beds of the lower Toronto Formation (the Don beds) which contained warm climate floral and faunal assemblages.

On top of these, and exposed in the subway, were the interstadial 'near glacial' climate Scarborough beds. The Bloor beds (varved clays) capped the Scarborough beds and were followed by the Leaside Till and the Iroquois and late Wisconsinan sands. Extensive laboratory analyses were also undertaken.

The author concludes that only two glacials occurred or were seen at Toronto, and were separated by one interglacial and one fluctuating interstadial.

Putnam, D.F., Watt, A.K., Deane, R.E., and Tovell, W.M.
1948: Toronto-Barrie, Ontario; Friends of Pleistocene Geology Guidebook.

This guidebook presents an overview of the Pleistocene geology between Toronto and Barrie. In the Toronto region three sites were visited: the Don Valley Brickyard, the Guild Inn at Scarborough Bluffs, and the Dutch Church section also at Scarborough. For each stop a section description is provided and major units noted.

Quigley, R.M.
1956: Study of the Occurrences, Properties and Origins of Varved Clays; Unpublished M.A.Sc. Thesis, University of Toronto.

Conditions of sedimentation were interpreted through thin section and hydrometer analysis for varved clay samples from Port Dover, Ontario; Don Valley, North Toronto, Ontario; and the Connecticut Valley, U.S.A.. The most important structures proved to be those which were preserved in the gradational zones between silt to clay, along with the structures found on top of the clay layers. The sedimentation patterns proved to be quite different for each location.

Radforth, N.W., and Terasmae, J.
1960: A Palynological Study Relating to the Pleistocene Toronto Formation; Canadian Journal of Botany, Volume 38, Number 4, p.571-580.

A palynological study was conducted on the Toronto Formation (Don and Scarborough beds) to determine the stratigraphic and chronologic position of these deposits.

Evidence supplied by lithology and the pollen and spore assemblages indicate that the Don beds belong to the Sangamonian interglacial. During deposition of the Don beds a thermal maximum of approximately 5° Fahrenheit warmer than present occurred. The upper part of the Don beds indicate that cooler climatic conditions prevailed during deposition of the sediments. Between the Don and Scarborough beds, both a botanical and stratigraphic hiatus is indicated. The Scarborough beds were found to contain a pollen assemblage comparable with the boreal forest region. The upper part of the Scarborough yielded a more subarctic flora. It is suggested that the Scarborough beds are pre-Wisconsinan in age.

Sado, E.V., White, O.L., Barnett, P.J., and Sharpe, D.R.
1984: The Glacial Geology, Stratigraphy and Geomorphology of the North Toronto Area: A Field Excursion; Correlation of Quaternary Chronologies Symposium, Abstracts with Program and Field Guide, York University, Toronto, p.505-517.

This field excursion examines and discusses glacial deposits in regions to the north and northwest of Toronto.

The first stop at Woodbridge revealed beds which are thought to represent the York Till, Scarborough Formation, Sunnybrook Till, Wentworth Till, Halton Till, and Wildfield Till. Many of these beds are thought to be correlative with units exposed at the Don Valley Brickyard and the Scarborough Bluffs.

The other stops (Humber River, Etobicoke Creek, Oak Ridges Moraine and Kettleby Creek) all deal with northern Toronto sections.

Sado, E.V., White, O.L., and Lee, P.K.
1985: The Urban and Environmental Geology of the Toronto Region; Edgeo Conference, National Association of Geology Teachers, Eastern Section Meeting, Ontario Association for Geographic and Environmental Education, Spring Conference Field trip Guidebook, Toronto, Ontario, 32p.

The geology of the Toronto-Hamilton area influenced the urban and environmental development of the area. The glacial deposits of the area are stated to be well known and some have gained international recognition. The Don Valley Brickyard provides vital information on the pre-Wisconsinan deposits of the area. The surface geology of Toronto is reasonably well known; however, the subsurface remains poorly known in some areas. The subsurface geology controls groundwater pressure and movement which in turn affects slope stability and subsurface engineering.

Sado, E.V., and Powell, R.D.
1984: The Geology and Slope Stability Problems in the Metropolitan Toronto Region; Field Trip Guide 3, IVth International Symposium on Landslides, 56p.

This report focuses on the geology, slope stability problems, and slope stabilization programs of the Toronto region.

The glacial deposits were previously studied and thus the stratigraphic framework and depositional environments of the strata were well known. Well exposed sections such as those at the Don Valley Brickyard, Scarborough Bluffs, and in river valleys provided much of the basic geological knowledge. This knowledge is invaluable for research or geotechnical studies.

Slope stability work was directed toward lake bluff erosion and riverbank erosion problems. The Metropolitan Toronto and Region Conservation Authority undertook a comprehensive program of watershed management and shoreline protection in 1957. A number of reports, both by public and private organizations, deal with specific erosion and slope stability programs of the area. A recent project dealt with the Don Valley Brickyards and the efforts to preserve the site.

Sauriol, C.
1981: Remembering the Don; Consolidated Amethyst Communications Limited, Scarborough, 150p.

This book provides a compilation of the author's writings regarding the Don River Valley.

One of Sauriol's articles outlines the beginnings of the Don Valley Brickworks. In the Spring of 1882, William Taylor and a helper were at work erecting a fence in the Don Valley. The clay

being brought to the surface by the posthole digging caught the attention of Mr. Taylor, who became curious as to its possibilities for brick-making. Later, Mr. Taylor packed two cigar boxes with clay and took them to a local brickworks. Here, Sauriol stated, a discussion took place between Mr. Taylor and the brickwork's owner as to the colour of brick which would be produced. Mr. Taylor suggested the clay would produce red bricks, which in fact it did. Mr. Taylor and his two brothers subsequently opened a brickworks on the site. The clay produced bricks of high quality, which won the Taylor brothers numerous medals in industrial fairs.

Scudder, S.H.

1877: Description of Two Species of Carabidae Found in Interglacial Deposits of Scarboro' Heights, Near Toronto, Canada; Bulletin of the United States Geological, Geographical Survey of the Territories, Volume B3, p.763-764.

1886: The Operations of a Prehistoric Beetle; Canadian Entomologist, Volume 18, Number 10, p.194-196.

A small twig of juniper taken from the interglacial beds at Scarborough exhibited the marks of beetle borings. The nature of the borings indicated that they were made by some species of Scolytidae and apparently one of the Hylurgini.

The mode of origin of the larval mines was different from anything previously described. The author speculates that a nonspecies of Scolytidae, which would presently inhabit northern Canada, could have produced the borings. Scudder was not aware of any modern day northern dwelling compatriate.

1890a: General Meeting; Boston Society of Natural History Proceedings, Volume 24, p.467-468.

The clays at Scarborough were found to contain a large insect assemblage. Twenty-nine species representing five families and fifteen genera were identified. The most common family was the Carabidae followed by Staphylinidae, Hydrophilidae, Chrysomelidae, and Scolytidae. The species are stated to be indigenous to the soil and perhaps came from a more northerly location than that from which they were found. Not one of the species could be referred to existing ones; however the nearest similar species is speculated to inhabit the Lake Superior-Hudson Bay region. On the whole the fauna had a boreal aspect.

1890b: The Fossil Insects of North America; United States Geological Survey, Report 8.

1890c: The Tertiary Insects of North America; Article *in* Report of the United States Geological, Geographical Survey of the Territories, edited by F.V. Hayden, Volume 13.

1895: The Coleoptera Hitherto Found Fossil in Canada; Geological Survey of Canada, Contributions to Canadian Paleontology, Volume 2, Number 1, p.27-56.

Coleoptera were identified from seven localities in Canada including a site in the post-Pliocene deposits at Scarborough. The Scarborough heights section yielded twenty-nine species. Four of these species were found by G.S. Hinde at Cleveland in clay beds similar to those at Scarborough and were considered equivalent. The fossils collected by Hinde represent five families and fifteen genera of beetles. The beetle families identified are Carabidae, most common, Staphylinidae, Hydrophilidae, Chrysomelidae, and Scolytidae. The assemblage of forms suggest that they inhabited an environment similar to more northern parts of Canada. On the whole, the fauna had a boreal aspect. A number of plates with identified species are also included.

1900: Additions to the Coleopterus Fauna of the Interglacial Clays of the Toronto District; Geological Survey of Canada, Contributions to Canadian Paleontology, Volume 2, Number 11, p.67-92.

This report provides additional information on the Coleopterus fauna which was previously investigated by Scudder in 1895. None of the species identified in the first report could be related to living forms.

Scudder identified additional species from material sent to him by A.P. Coleman. The sediments contained 54 species of beetles from 6 families. Three new families were identified, being Dytiscidae, Gyrinidae, and Curculionidae.

Of the 54 species, only 7 were previously found in the beds, and of the additional 47 species all but 2 were considered to be extinct. The number of known interglacial species totaled 76, representing 8 families.

The fauna is concluded to belong to a boreal environment. An appendix to the report is provided by Dr. A.P. Hopkins regarding borings of the Scolytid, *Phloeosinus Squalidens Scudd* in a piece of *Thiya sp.* (cedar) found in the interglacial beds at Toronto. A number of photographic plates of species are included.

Semkow, W.

1949: A Section of the Pleistocene in the Vicinity of Birchmount Avenue in Scarborough, Ontario: Unpublished B.A.Sc. Thesis, University of Toronto.

Sharpe, D.R.

1980: Quaternary Geology of Toronto and Surrounding Area; Ontario Geological Survey, Preliminary Map P.2204, Geological Series, scale 1:100 000.

This map provides a summary of the Quaternary geology of the Toronto region. The landscape and sediment strata of the region resulted from both glacial and recent deposits and events.

The map outlines the surficial deposits of Toronto and surrounding areas. Cross sections of deposits exposed in subway cuts (Yonge St. and Bloor-

Danforth lines) are shown and provide the third dimension to the stratigraphy. Details of the geology of well known or reference sections, including the Don Valley Brickyard, Woodbridge, and Scarborough Bluffs are also provided.

1986b: Quaternary Stratigraphy of Toronto, Ontario; Geological Society of America, DNAG (Decade of North American Geologists) Field Guide, in press.

This field guide deals with three Toronto sites: the Sunnypoint Section at the Scarborough Bluffs; the Don Valley Brickyards; and the Woodbridge Railroad Cut. These sites revealed large portions of the Sangamonian interglacial and Wisconsinan glacial events in the Great Lakes region. Re-evaluation of lithostratigraphic sections at the Scarborough Bluffs is a major focus.

The Sunnypoint section shows the most complete set of strata in the Toronto area. A series of four diamictons and intercalated stratified sediment resting on thick deltaic sand and clay is revealed.

The best exposure of the warm climate Don Formation was found along with the Illinoian York Till in the Don Valley Brickyards. The York Till was best exposed at the Woodbridge Railway cut. Fossils found at these sites indicate major climatic shifts over the last 125 000 years.

Sharpe, D.R., and Barnett, P.J.

1985: Significance of Sedimentological Studies on the Wisconsinan Stratigraphy of Southern Ontario; Geographie Physique et Quaternaire, Volume 39, Number 3, p.255-273.

The known Wisconsinan stratigraphy in Southern Ontario was affected by detailed facies mapping of Lake Erie and Ontario bluff sections and other sites. This detailed work: 1) improves the understanding of depositional processes and environments for several major rock units; 2) allows better drift correlation; and 3) raises questions about previous interpretations and stratigraphy. Sedimentological studies which had surface land form or geomorphological control were found to be most useful. The interpretation of older buried sediments was hampered by the lack of landform control. Questions regarding the stratigraphic and sedimentological interpretation of certain formations, such as the Pottery Road Formation which was best exposed at the Toronto Brickyard, remain. The authors state that further studies on this and other formations might alter the Wisconsinan stratigraphy.

Simpson, C.T.

1893: On Some Fossil Unios and Other Freshwater Shells From the Drift at Toronto, Canada. With a Review of the Distribution of the Unionidae of Northeastern North America; United States National Museum Proceedings, Volume 16, p.591-595.

Several fossil Unios and other fresh water shells were examined by the Smithsonian Institute at the request of A.P. Coleman, who collected the samples from a railway cut 20 to 25 feet above the Don River in Toronto. These fossils were found in a bed of sand which lay between two glacial beds. All of the identified fossils were found to be in existence today and mainly restricted to the Mississippi River Valley.

Simpson suggested that the Mississippi Valley Unios migrated to the Great Lakes region when the ice retreated. They could not, however, establish themselves in the region due to a subsequent readvancement of the ice. Complications, such as drainage pattern changes through ice melting, might have prevented the Unios from returning to the Toronto region after the ice once more disappeared.

Sly, P.G., and Lewis, C.F.M.

1972: The Great Lakes of Canada—Quaternary Geology and Limnology; XXIV International Geological Congress Guidebook, Volume A43, 92p.

This field trip guide outlines the glacial, interglacial, and postglacial Quaternary history of southern Ontario. Cross-lake traverses by boat, lake bottom coring, shoreline sections, and excursions to on-shore locations were utilized to illustrate the geology. A visit to the Toronto area included an excursion to the Don Valley Brick yard. The Illinoian, York Till, and Sangamonian Don Beds were of special interest at this site.

Stearn, C.W., Carroll, R.L. and Clark T.H.

1978: Late Cenozoic Glaciation; Article *in* Geological Evolution of North America, Third Edition, John Wiley and Sons, New York, 566p.

This book provides a summary of the geological history of North America. One chapter is devoted to a review of the late Cenozoic glaciation. The Toronto area and specifically exposures at the Don Valley Brickyard are used to explain glacial stratigraphy and the nature of interglacial sediments.

Terasmae, J.

1955: A Palynological Study Relating to the Toronto Formation (Ontario) and the Pleistocene Deposits in the St. Lawrence Lowland (Quebec); Unpublished Ph.D. Thesis, McMaster University, Hamilton, Ontario.

1960: A Palynological Study of Pleistocene Interglacial Beds at Toronto, Ontario; Geological Survey of Canada Bulletin, Volume 56, p.24-40.

Interglacial sediments, well exposed along the shore of Lake Ontario east of Toronto and in the Don Valley Brickyard, were studied. The basal beds consist of a thin till named the York Till. This till is separated by a time interval from the overlying nonglacial beds. The interglacial beds are subdivided into the Don beds at the base and the Scarborough beds above. The beds are separated by a hiatus and possibly by a minor glacial event. Overlying the Scarborough beds in ascending order are the Sunnybrook Till, Dan-

forth beds (Lower Thorncliffe to Meadowcliffe Till), and the Thorncliffe beds.

Palynological and paleontological studies of the Don and Scarborough beds provided valuable insight into the paleoclimates. The Don beds were deposited at a time when the annual temperature was 5° Fahrenheit warmer than now. Especially revealing is the identification of pollen from *Liquidambar sp.* (Sweet Gum tree). The Scarborough beds were laid down when the climate was an average of 10° colder.

The Don beds were thought to have been deposited during the Sangamonian interglacial. The Scarborough beds were tentatively assigned to the St. Pierre interval and might have formed in a substage prior to the Wisconsinan proper.

Terasmae, J., Karrow, P.F., and Dreimanis, A.
1972: Quaternary Stratigraphy and Geomorphology of the Eastern Great Lakes Region of Southern Ontario; XXIV International Geological Congress Guidebook, Volume A24, 75p.

The basis of this field trip guide is to provide an outline of the geology, geomorphology, and stratigraphy for southern Ontario. Quaternary geology was emphasized.

A major part of the excursion focuses on the Quaternary geology of Toronto. The sequence of deposits is one of the most well known in North America. The age of the interglacial beds provide a major correlation problem over the years. Studies in Europe and America helped define the classification. The Illinoian consists of the York Till; Sangamonian deposits include the Don and Scarborough Formations. Revised lists of floral and faunal species are included as are radiocarbon dates.

Tovell, W.M., and Freeman, E.B.
1978: Southeastern Ontario: A Geological Overview; p.148-159 *in* Toronto 1978, Fieldtrips Guidebook, edited by A.L. Currie and W.O. Mackasey, Geological Society of America and Geological Association of Canada.

This field trip guide outlines major geological features of southeastern Ontario. Important sites visited in Toronto include the Don Valley Brick yard and Scarborough Bluffs.

The Don Valley Brickyard site had been under excavation for over 75 years. The Pleistocene section changed considerably over the years as the Pottery Road Formation was gradually exposed in the northeastern corner of the pit. The Pottery Road is stated to be a channel sand unit of sand and gravel and is correlated with the St. Pierre Interstadial. Pollen collected from the formation indicated a cool climate comparable to the underlying Scarborough Formation. It is possible that the pollen was reworked from the underlying Scarborough beds.

The Don Formation has yielded approximately 50 taxa of beetles including several types of water beetles. The Don Formation overlies the York Till which is thought to be at least 100 000 years old.

Upham, W.
1895: The Climatic Conditions Shown by North American Interglacial Deposits; American Geologist, Volume 15, Number 5, p.273-295.

An excavation in the stratified drift and till beside the Don River in Toronto, Ontario yielded many fresh water molluscs (Pleurocera, Valvata, Sphaerium, and Unios), and at least three trees (Fraxinus, Quercus, and Taxus).

Two closely spaced retreats and advances of glacial ice deposited thick boulder clays at Scarborough and thin units westward at Toronto. The thick Scarborough stratified beds accumulated as a delta in a large lake. Upham felt that such a sediment load was only probable from englacial drift within the drainage area of the delta-forming streams. This meant close proximity to the ice margin.

Upham believed that ice-damming of the St. Lawrence formed Lake Iroquois and then uplift of the land raised the shoreline to a height of almost 200 feet above Lake Ontario at Toronto.

1895: The Climatic Conditions Shown by North American Interglacial Deposits; American Geologist, Volume 16, Number 2, p.105-106.

At Toronto and Scarborough, Ontario glacial oscillations occurred, as shown by interbedded tills and fossiliferous stratified gravel, sand, and clay.

During deposition of the Scarborough drift the climate was no milder than today. This was determined through the low altitude of the land, the proximity to Lake Algonquin, and by the eastward and northeastward surface-atmospheric currents and storms.

The trees of the time, whose wood was found in the interglacial Toronto beds, had their northernmost limits in the same region today as during the interglacial periods in Toronto.

1901: The Toronto and Scarboro Drift Series; American Geologist, Volume 28, p.306-316.

The Toronto interglacial beds were interpreted to be part of a delta which was built on a lakeward-dipping bedrock slope. After the delta was built to a height of 200 feet, the same streams which built it began to incise channels into the structure. Downcutting by streams was thought to be the result of streams being relieved of their sediments. The whole interglacial period was thought to have lasted only a few hundred or possibly a thousand years with the ice sheet being close by at all times.

Ure, R.J.
1950: An Investigation of the Concretions in the Interglacial in the North Toronto Region; Unpublished B.A.Sc. Thesis, University of Toronto.

Wallace, R.C.
1927: Varve Materials and Banded Rocks; Royal Society of Canada Transactions (Third Series), Volume 21, Number 4, p.109-118.

This study looks at the relative mechanical and chemical composition of seasonally deposited varve materials. Three sample locations are used: the Don Valley interglacial beds in Toronto, Herb Lake in northern Manitoba, and Cross Lake in eastern Manitoba.

In the analyses, a definite increase in alumina, ferric oxide, and potash from summer to winter, and a decrease in lime content over the same period, was noted.

The varves from the Don Valley were very distinctively graded as to summer (coarse and light coloured) and winter (fine and dark coloured). This sharp gradation in both size and colour indicated one half inch of summer deposition and one quarter inch of winter deposition on average for the Don Valley interglacial varves.

Watt, A.K.
1954: Correlation of the Pleistocene Geology as Seen in the Subway With that of the Toronto Region, Canada; Geological Association of Canada Proceedings, Volume 6, p.69-81.

Almost all Toronto area Pleistocene formations were exposed during the subway excavations. Three tills were exposed, the lowest of which was thought to be Illinoian age as it underlay presumed Sangamonian interglacial beds (Don sands and Scarborough clays) and a Wisconsinan aged till. Fossil peats under the Wisconsinan till gave ages which indicated that land above the Lake Iroquois shore existed before the Wisconsinan glaciation. The interstage sands were overlain by at least one upper Wisconsinan till which had since been removed through erosion by glaciers, streams, and lakes. A lower Wisconsinan till was exposed at the Don Valley Brickyards.

Watt, A.K., Chapman, L.J., Putnam, D.F., and Tovell, W.M.
1953: Glacial Geology of the Toronto-Orangeville Area, Ontario; Geological Society of America Guidebook to Trip No. 3.

This field guide deals with Pleistocene deposits of Toronto as well as north and northwest of Toronto.

The authors suggest that the Toronto interglacial beds, made up of the warm climate Don beds and the cooler climate Scarborough clays and sands as seen at both the Don Valley Brickyards and the Scarborough Bluffs, are Sangamonian in age. The overlying series of tills are Wisconsinan in age. The remainder of the guide deals with deposits north and northwest of Toronto.

Westgate, J.A., and Sharpe, D.R.
1980: Quaternary Geology of the Metro Toronto-Markham Region Field Guidebook; Glacial Geology in the Service of Mineral Exploration: A Workshop, University of Toronto.

This fieldtrip guide outlines elements of the regional geology for Toronto and Markham. A number of sites were visited including a stop at the Don Valley Brickyard. At the brickyard the York Till is used as an example of good lodgement or basal till. A number of questions are posed with regard to the depositional characteristics of the Sunnybrook Drift.

Additional field stops included the Oak Ridges Moraine and the Lake Ontario bluffs.

White, O.L., and Karrow, P.F.
1971: New Evidence for Spencer's Laurentian River; p.394-400 *in* Proceedings of the Fourteenth Conference on Great Lakes Research, edited by D.V. Anderson and J.S. Seddon, The International Association for Great Lakes Research.

During the late 1800s, Spencer (1907) suggested that a major bedrock valley existed between Georgian Bay and Lake Ontario. A large river, the Laurentian River as named by Spencer, flowed through this valley, debouching into Lake Ontario east of Toronto. It was later suggested by Coleman that the Toronto interglacial deposits were deposited by a successor of the Laurentian River. Coleman suggested that this river entered Lake Ontario at Humber Bay. This report utilizes data obtained from recent waterwell records. It concludes that the location of the valley is southwest of Lake Simcoe and underlays the present Don River. It also suggests that this drainageway was still active at the end of the last interglacial, some 70 000 years ago.

Williams, N.E.
1975: Interglacial Caddisfly (Insecta: Trichoptera) Remains as an Aid in Describing Past Environmental Conditions; Quaternary Non-Marine Paleoecology Conference, Program with Abstracts, Waterloo, Ontario.

About twenty Caddisfly taxa were recovered from interglacial sediments at the Don Valley Brick yard. One grouping was noted to be typical of certain present day Great Lakes shores.

Williams, N.E., Westgate, J.A., Williams, D.D., Morgan, A., and Morgan, A.V.
1981: Invertebrate Fossils (Insecta: Trichoptera, Diptera, Coleoptera) From the Pleistocene Scarborough Formation at Toronto, Ontario, and Their Paleoenvironmental Significance; Quaternary Research, Volume 16, p.146-166.

The Pleistocene Scarborough Formation at Toronto formed as a delta, deposited at the mouth of a large river which drained from a lake located to the north. The lake level suggested that drainage through the St. Lawrence Lowlands was prevented by a glacier.

The Scarborough sediments yielded numerous remains of larval caddisflies, chironomids, and beetles. The youngest horizon sampled yielded cool climate fossils belonging to a boreal forest type environment. Large climatic differences were found between the upper and lower beds of the formation.

Williams, N.E., and Morgan, A.V.
1977: Fossil Caddisflies (Insecta; Trichoptera) from the Don Formation, Toronto, Ontario, and Their Use in Paleoecology; Canadian Journal of Zoology, Volume 55, p.519-527.

Fragments of Caddisfly larvae were recovered from the Sangamonian Don Formation at the Don Valley Brickyards. A total of 22 taxa were identified. They are divided into two groups; a lake assemblage and a river assemblage. The lake assemblage taxa are noted to be all found in the present day Great Lakes. The river assemblage suggests primarily low density deciduous vegetative cover. Again the climate is suggested to be very similar to the present Great Lakes region.

The nature of the sediments indicates that deposition of the lower Don beds occurred over a thin substrate of York Till, or directly upon the Ordovician shale. Quiet water deposition was likely. The sandy cross-bedded sands midway in the section suggest a more littoral environment, whether due to falling lake level or a prograding delta was not known. The upper part of the Don beds seem to indicate deeper water conditions and possible fluctuating water levels.

Wilmarth, M.G.
1938: Lexicon of Geologic Names of the United States (including Alaska); United States Geological Survey, Bulletin 896.

This book includes the names, ages, and descriptions of geologic units used in the United States, Canada, Mexico, the West Indies, Central America, and Hawaii.

A description of the Toronto Formation is provided and the speculations of various authors as to its age are noted. Upham suggested the Toronto Formation belongs in the Champlain epoch, while Chamberlin stated its position as uncertain but might be later than the Wisconsinan Formation.

Wilson, A.W.G.
1901: Physical Geology of Central Ontario; Royal Canadian Institute Transactions, Volume 7, Number 1, p.139-186.

This paper presents a summary of the geology of central Ontario covering Precambrian to recent time. The Pleistocene geology was not well known. The best known localities were at the Scarborough Heights and Taylor Brickpit sites at Toronto.

The fossils from the lowest group of interglacial beds at Toronto indicated a climate perhaps similar to Ohio. During this time the lake was thought to be connected with the Mississippi drainage system. This connection might have existed previous to the first ice advance. As the interglacial beds were deposited it was not known whether the ice had fully withdrawn from the region. The upper interglacial beds contained fossils which indicated a climate similar to the present day Labrador coast or lower Gulf of St. Lawrence. The close of the interglacial was followed by a period of considerable erosion. The interglacial beds of later epochs were poorly known.

Photographs of the Taylor Brickpit and Scarborough Bluffs during the late 1800s are included.

Wright, G.F.
1914a: Age of the Glacial Deposits in the Don Valley, Toronto, Ontario (abstract); Geological Society of America Bulletin, Volume 25, p.71-73.

The age of the Don glacial deposits are in conflict with the evidence of a more recent ice retreat from the southern part of Lake Erie, where the southern shoreline of Lake Warren is thought to be not more than 12 000 to 15 000 years old. The lakes that formed the ridges south of Lake Erie are thought to have lasted only 1000 years, whereas the sediments exposed in the terrace at Scarborough represent some 3000 years. This time span is thought to represent the opening of drainage south of the glacial ice in the Mohawk Valley and the final opening through the St. Lawrence. The fluviatile glacial deposits in the Don Valley accumulated during this time.

The first ice advance across the Toronto region most likely proceeded from the Keewatin centre and, following a minor retreat, gave way to the ice from Labrador. It was probable that the warm climate fossils of the Don beds were specimens of an earlier time which were incorporated by the first ice advance. The sea shells of Moel Tryfaen, Wales, and Macclesfield, England, were believed by some geologists to have been deposited in such a manner.

Wright, G.F.
1914b: Age of the Glacial Deposits in the Don Valley, Toronto, Ontario; Geological Society of America Bulletin, Volume 25, p.205-214.

The occurrence of warm climate fossils in the interglacial deposits of the Don Valley was thought by many to record an immense interval of time between the two bounding ice sheets. A contrary conclusion is reached by the author.

In front of the Muir glacier in Alaska, fluvial deposits enveloped tree roots and stumps and were subsequently covered by till. It was believed that the warm climate specimens at Toronto were derived in a similar manner; that is, underlying Tertiary-aged deposits, were plowed up by an ice advance and raised to the level where they were found. A similar situation is cited from Moel Tryfaen, Wales, where well preserved shells were thought to have been pushed up by glacial action to a height of some 1000 feet above sea level.

The depositional scenario at Toronto is summarized as follows. First the Keewatin ice sheet pushed southward to the Mississippi and east to Pennsylvania and Toronto. The Toronto area was occupied by plants and animals which now exist only some distance to the south. At that time the lower Don beds were deposited. Later, following the retreat of the Keewatin ice, the Labrador ice advanced and covered Toronto. During this advance the Scarborough beds were deposited and some of the fossils from the Don beds were incorporated into the Scarborough beds. Upon retreat of the Labrador ice, Lake Warren came into existence and with further retreat of the ice eastward, Lake Iroquois was formed. Thus, suggests Wright, the whole sequence of events at Toronto could occur over a very short time.

Wright, W.B.
1937: The Glaciation of North America; p.194-195 *in* The Quaternary Ice Age, 2nd Edition.

This book includes a chapter on the movements and deposits of the Quaternary ice sheets.

The most famous interglacial deposits (the Toronto Formation) were found in the Don Valley and along the Scarborough Bluffs in Toronto. The sediment sequence showed an old till overlain by interglacial silts (fossiliferous), a calcareous till, glacial sands and gravels, and englacial upper till. Mature valleys were formed during the interglacial period and ice proceeded to fill them in with drift. Fossil indicators suggested a climate as warm or warmer during deposition of the Toronto Formation as compared to present day Toronto.